$9.95

The XT-AT HANDBOOK

for Engineers, Programmers,

and Other Serious PC/XT and PC/AT Users

John P. Choisser
John O. Foster

Fourth Edition

A Collection of Hardware and Software Facts and Data on the PC-Compatible Family and Its Operating System

The XT-AT HANDBOOK

for Engineers, Programmers,

and Other Serious PC/XT and PC/AT Users

John P. Choisser
John O. Foster

Fourth Edition

A Collection of Hardware and Software Facts and Data on the PC-Compatible Family and Its Operating System

Copyright Annabooks 1989 - 1993

15010 Avenue of Science, Suite. 101
San Diego, CA 92128

The contents of this publication may not be reproduced in any form by any means, in part or in whole, without the prior written permission of the publisher.

ISBN 0-929392-00-0

The authors and publishers make no warranty of any kind with regard to this material, including, but not limited to, the implied warranties of merchantability and fitness for any particular purpose. Neither shall the authors or publishers be liable for any errors contained herein or for incidental or consequential damages in connection with the furnishing or use of this material.

Fourth Edition

Twelfth Printing

April 1993

MS-DOS is a registered trademark of Microsoft Corporation.

PC-DOS, PC/XT, PC/AT, and IBM are registered trademarks of IBM Corporation.

Intel is a registered trademark of the Intel Corporation.

BiosKit, SysVue, PromKit, and SysKit are trademarks of Annabooks

INTRODUCTION

Novice or expert, we expect that you are going to find this book useful. If you're a novice, the contents are going to be a stimulating introduction to the inside goings-on that you will want to learn more about. If you are an expert, you will find this handbook to be a handy memory jogger. Frequently the facts needed are buried in a manual in the other room. This book is in your pocket.

This handbook is intended to be a helpful reference for both hardware and software information. We have selected the items that most often cause us to reach for the manuals, whether the question involves hooking up a printer or hooking into the BIOS.

For additional information on these subjects, you should refer to the manuals and technical references for the computer and software you are using.

We want to continually improve this handbook, so please write to us if you spot any errors or think of any additional material we should include. We hope it will be as useful for you as it is for us.

Table of Contents

* denotes new or updated for Fourth Edition

1. Diagnostic Error Codes 4
2. POST Notes 10
3. Diagnostic Beep Codes 11
4. CPU Summary * 13
5. PC 62 Pin Connector 14
6. PC 26 Pin Connector 15
7. EISA Pin Assignments * 16
8. ISA/EISA Signal Names * 17
9. Bus Signal Summary * 18
10. XT Add-On Card Dimensions 22
11. AT Add-On Card Dimensions 23
12. Card Bracket Position * 24
13. EISA Add-On Card Dimensions * 25
14. Power Cables 26
15. Display Cables 27
16. XT Speaker Cable Connector 28
17. Keyboard Cable 28
18. Parallel Printer Cable 29
19. Disk Cables 30
20. RS-232C Cables 31
21. Game Controller Adapter Cable 32
22. Memory Map 33
23. I/O Map 34
24. BIOS Data Area 35
25. Interrupt Map 37
26. Hardware Interrupts 39
27. DMA Channels 39
28. BIOS Entry Points 40
29. Hard Drive Types 41
30. AT CMOS Memory 43
31. Switch Settings 45
32. Video 46
33. 8237 DMA Controller(s) 49
34. 8255 PIO (PC/XT) 50
35. AT 8255 Equivalent 51
36. 8259 Interrupt Controller(s) 53
37. 8253/8254 Counter/Timer 54

Table of Contents (cont.)

38. 8250 Serial Chip Notes 55
39. 8250 Register Descriptions 56
40. Logical & Physical Devices 57
41. User ROM Scan 58
42. PC/XT Keyboard Scan Codes 59
43. AT 84 Key Keyboard Scan Codes 61
44. AT 101 Key Keyboard Scan Codes 63
45. AT Keyboard Commands 66
46. ASCII Control Codes 67
47. Screen Codes 68
48. Line Drawing Character Codes 72
49. DOS Commands 74
50. DEBUG Commands 77
51. EDLIN Commands 78
52. BATCH Commands 79
53. DOS Keystrokes 80
54. CONFIG.SYS Commands 81
55. LIB Commands 82
56. Floppy Disk Formats * 83
57. Disk Controller Function Summary * 85
58. ST506 & ESDI Cables * 86
59. ST506 & ESDI Signals * 87
60. SCSI Cable * 88
61. SCSI Signals * 89
62. IDE Cable * 90
63. IDE Signals * 91
64. Hex Math 93

1. Diagnostic Error Codes

The Power-On Diagnostics (POD) and other Diagnostics test various parts of the system and display a Problem Isolation Code (PIC) if an error is detected. Keep in mind that not all actual hardware errors may be detectable with a software test routine. Following is a list compiled from various sources, which are believed to be reasonably accurate. PIC codes displayed from other than IBM test routines may have different definitions. Some of these codes are applicable only to particular machines (PC or XT or AT), and also to the specific options installed in a machine; therefore there may be differing interpretations of the numeric codes in some instances. In general, a display of a PIC number ending in "00" indicates that the tests for a particular category were passed successfully, a code with an ending other than "00" indicates a failure during the test routine.

Error Messages Displayed on Video Device

- 010 - Start
- 020 - Power Supply
- 100 - System Board
  - 101 - 8259 Interrupt Failure
  - 102 - 8253 Timer Failure
  - 103 - 8253 Timer Interrupt Failure
  - 104 - Protected Mode Failure
  - 105 - 8742 Command Not Accepted
  - 106 - Logic Test Failure
  - 107 - NMI Test Failure
  - 108 - 8253 Timer Failure
  - 109 - LMCS Test Failure or DMA test failure
  - 114 - Option ROM checksum error
  - 121 - Unexpected hardware interrupt
  - 130 - Shutdown/Restart error
  - 131 - Cassette wrap failed.
  - 161 - Battery Failure (Run Setup)
  - 162 - Configuration Incorrect (Run Setup)
  - 163 - Time and/or Date Incorrect (Run Setup)
  - 164 - Memory Size Incorrect (Run Setup)
  - 165 - Invalid Adapter Configuration
  - 166 - Non-existent Adapter Configuration
  - 167 - Invalid Diskette Adapter Configuration
  - 168 - Invalid System Configuration
  - 199 - User configuration incorrect (Run Setup)
- 200 - System Memory
  - 201 - Memory Error
  - 202 - Memory Address Lines 00-15
  - 203 - Memory Address Lines 16-23

1. **Diagnostic Error Codes** (cont.)

- 300 - Keyboard
  - 301 - Bad reset; if stuck key - scan code is displayed
  - 302 - Keyswitch is Locked
  - 303 - Keyboard or System Error
  - 304 - Keyboard Clock Line Error
  - 306 - Keyboard Data Line Error
  - 307 - Keyboard Stuck Key Error
- 400 - Monochrome Display Adapter
  - 401 - MDA memory or H. sync failed
  - 408 - Display attributes failure.
  - 416 - Character set failure
  - 424 - 80X25 mode failure
  - 432 - Parallel port test on MDA failed
- 500 - Color/Graphics Adapter
  - 501 - CGA memory or H. Sync failed
  - 508 - Display attribute failure
  - 516 - Character set failure
  - 524 - 80x25 mode failure
  - 532 - 40x25 mode failure
  - 540 - 320x200 graphics mode failure
  - 548 - 640x200 graphics mode failure
- 600 - Floppy Disk Adapter
  - 601 - Disk power on diagnostics failed
  - 602 - Floppy Disk Boot Error
  - 602 - Disk test failed
  - 606 - Disk verify function failed
  - 607 - Write protected disk.
  - 608 - Bad command disk status returned
  - 610 - Disk initialization failed
  - 611 - Timeout - disk status returned
  - 612 - Bad NEC - disk status returned
  - 613 - Bad DMA - disk status returned
  - 621 - Bad SEEK - disk status returned
  - 622 - Bad CRC - disk status returned
  - 623 - Record not found - disk status returned
  - 624 - Bad address mark - disk status returned
  - 625 - Bad NEC seek - disk status returned
  - 626 - Disk data compare error
- 700 - 8087 math coprocessor
- 800 - Reserved
- 900 - Parallel Printer Adapter
  - 901 - Parallel printer adapter test failed

1. **Diagnostic Error Codes** (cont.)

1000 - Alternate parallel printer adapter
1100 - Async Adapter
  1101 - Async adapter failed
1200 - Alt. Async Adapter
  1201 - Alt. Async adapter failed
1300 - Game Control Adapter
  1301 - Game control adapter failed
  1302 - Joystick failed
1400 - Matrix Printer
  1401 - Printer failed
1500 - SDLC Communication Adapter
  1510 - 8255 port B failure
  1511 - 8255 port A failure
  1512 - 8255 port C failure
  1513 - 8253 timer 1 did not reach terminal count
  1514 - 8253 timer 1 stuck on
  1515 - 8253 timer 0 did not reach terminal count
  1516 - 8253 timer 0 stuck on
  1517 - 8253 timer 2 did not reach terminal count
  1518 - 8253 timer 2 stuck on
  1519 - 8273 port B error
  1520 - 8273 port A error
  1521 - 8273 command/read timeout
  1522 - Interrupt level 4 failure
  1523 - Ring Indicate stuck on
  1524 - Receive clock stuck on
  1525 - Transmit clock stuck on
  1526 - Test indicate stuck on
  1527 - Ring indicate not on
  1528 - Receive clock not on
  1529 - Transmit clock not on
  1530 - Test indicate not on
  1531 - Data set ready not on
  1532 - Carrier detect not on
  1533 - Clear to send not on
  1534 - Data set ready stuck on
  1536 - Clear to send stuck on
  1537 - Level 3 interrupt failure
  1538 - Receive interrupt results error
  1539 - Wrap data miscompare
  1540 - DMA channel 1 error
  1541 - DMA channel 1 error
  1542 - Error in 8273 status
  1547 - Stray interrupt level 4
  1548 - Stray interrupt level 3
  1549 - Interrupt timeout

1. **Diagnostic Error Codes** (cont.)

- 16XX - Display Emulation Error (327X,5520, 525X)
- 1700 - Hard Disk Drive
  - 1701 - Hard disk POST error
  - 1702 - Hard disk adapter error
  - 1703 - Hard disk drive error
  - 1704 - Hard disk adapter or drive error
  - 1780 - Hard Disk 0 Failed
  - 1781 - Hard Disk 1 Failed
  - 1782 - Hard Disk Controller Error
  - 1790 - Hard Disk 0 Error
  - 1791 - Hard Disk 1 Error
- 1800 - Expansion Unit
  - 1801 - I/O Expansion unit POST error
  - 1810 - Enable/Disable failure
  - 1811 - Extender card wrap test failed (disabled)
  - 1812 - High order address lines failure (disabled)
  - 1813 - Wait state failure (disabled)
  - 1814 - Enable/Disable could not be set on
  - 1815 - Wait state failure (enabled)
  - 1816 - Extender card wrap test failed (enabled)
  - 1817 - High order address lines failure (enabled)
  - 1818 - Disable not functioning
  - 1819 - Wait request switch not set correctly
  - 1820 - Receiver card wrap test failure
  - 1821 - Receiver high order address lines failure
- 19XX - 3270 PC Attachment Card Errors
- 2000 - Bisync communications adapter errors
  - 2010 - 8255 port A failure
  - 2011 - 8255 port B failure
  - 2012 - 8255 port C failure
  - 2013 - 8253 timer 1 did not reach terminal count
  - 2014 - 8253 timer 1 stuck on
  - 2016 - 8253 timer 2 terminal count or stuck on
  - 2017 - 8251 Data set ready failed to come on
  - 2018 - 8251 Clear to send not sensed
  - 2019 - 8251 Data set ready stuck on
  - 2020 - 8251 Clear to send stuck on
  - 2021 - 8251 hardware reset failed
  - 2022 - 8251 software reset failed
  - 2023 - 8251 software "error reset" failed
  - 2024 - 8251 transmit ready did not come on
  - 2025 - 8251 receive ready did not come on
  - 2026 - 8251 could not force "overrun" error status
  - 2027 - Interrupt failure-no timer interrupt
  - 2028 - Interrupt failure-transmit, card or planar
  - 2029 - Interrupt failure-transmit, replace card

1. **Diagnostic Error Codes** (cont.)

2030 - Interrupt failure-receive, replace card or planar
2031 - Interrupt failure-receive, replace card
2033 - Ring indicate stuck on
2034 - Receive clock stuck on
2035 - Transmit clock stuck on
2036 - Test indicate stuck on
2037 - Ring indicate stuck on
2038 - Receive clock not on
2039 - Transmit clock not on
2040 - Test indicate not on
2041 - Data set ready not on
2042 - Carrier detect not on
2043 - Clear to send not on
2044 - Data set ready stuck on
2045 - Carrier detect stuck on
2046 - Clear to send stuck on
2047 - Unexpected transmit interrupt
2048 - Unexpected receive interrupt
2049 - Transmit data did not equal receive data
2050 - 8251 detected overrun error
2051 - Lost data set ready during data wrap
2052 - Receive timeout during data wrap

2100 - Alt. bisync communications adapter errors
2110 - 8255 port A failure
2111 - 8255 port B failure
2112 - 8255 port C failure
2113 - 8253 timer 1 did not reach terminal count
2114 - 8253 timer 1 stuck on
2116 - 8253 timer 2 did not reach terminal count
2117 - 8251 Date set ready failed to come on
2117 - 8251 Clear to send not sensed
2118 - 8251 Data set ready stuck on
2119 - 8251 Clear to send stuck on
2120 - 8251 hardware reset failed
2121 - 8251 software reset failed
2122 - 8251 software "error reset" failed
2123 - 8251 transmit ready did not come on
2124 - 8251 receive ready did not come on
2125 - 8251 could not force "overrun" error status
2126 - Interrupt failure-no timer interrupt
2128 - Interrupt failure-transmit, replace card
2129 - Interrupt failure-transmit, replace card
2130 - Interrupt failure-receive, replace card or planar
2131 - Interrupt failure-receive, replace card
2133 - Ring indicate stuck on
2134 - Receive clock stuck on
2135 - Transmit clock stuck on

1. **Diagnostic Error Codes** (cont.)

2136 - Test indicate stuck on
2137 - Ring indicate stuck on
2138 - Receive clock not on
2139 - Transmit clock not on
2140 - Test indicate not on
2142 - Data set ready not on
2142 - Carrier detect not on
2143 - Clear to send not on
2144 - Data set ready stuck on
2145 - Carrier detect stuck on
2146 - Clear to send stuck on
2147 - Unexpected transmit interrupt
2148 - Unexpected receive interrupt
2149 - Transmit data did not equal receive data
2150 - 8251 detected overrun error
2151 - Lost data set ready during data wrap
2152 - Receive timeout during data wrap

22XX - Cluster Adapter Errors
24XX - EGA Errors
2401 - Video Error
29XX - Color Matrix Printer Errors
3001 - Video Error
33XX - Compact Printer Errors
7000 - ChipSet CMOS RAM Error
7001 - ChipSet Shadow RAM Error
7002 - ChipSet CMOS RAM Configuration Error
8601 - Mouse Interface Command Error
8602 - Mouse Interface Test Error
8603 - Mouse Interface Timeout Error

2. POST Notes

The Power On System Test (POST) routines in the Bios perform tests, and initialize the circuitry on the motherboard and on peripheral adapter boards. The POST is reached by the powering-on or using the CTRL-ALT-DEL re-boot keystrokes. From the reset state, program execution begins at the beginning of the highest paragraph of memory. (F000:FFF0 for an 8088, FFFFF:0000 for an 80286) with a long jump to E000:E05B, where the POST sequence starts. The degree and manner of test/initialization will vary among the different brands of Bios'.
The usual sequence is:

- Do some CPU register checks
- Setup the 8253/8254 timer for RAM refresh timing
- Setup the DMA for RAM refresh on channel 0
- Verify that refresh is operating
- Test the low RAM (16-64K)
- Load Interrupt Vectors and assign a stack in the low RAM area.
- Initialize video and keyboard devices
- Size and test the remaining RAM
- Initialize the COM, LPT, and Game Ports
- Initialize the floppy disk system
- Initialize the hard disk system (for AT's)
- Scan the user rom area
- Call the Bootstrap Interrupt

3. Diagnostic Beep Codes

Audible (Beep) Signals - These signals may be generated for conditions detected before the display device is initialized, preventing a visual display of the problem.

The codes are shown as x-y-z where 2 - 2 - 1 represents 2 beeps - pause - 2 beeps - pause - 1 beep.

Fatal Errors

1 - 1 - 3	CMOS Failure
1 - 1 - 4	Bios Checksum failure
1 - 2 - 1	8253 Timer failure
1 - 2 - 2	DMA setup failure
1 - 2 - 3	DMA page register failure
1 - 3 - 1	RAM refresh not verified
1 - 3 - 3	Low 64K RAM failure
1 - 3 - 4	Low 64K RAM even/odd failure
1 - 4 - 1	Low 64K RAM address line failure
1 - 4 - 2	Low 64K RAM Parity error
2 - 1 - 1	Low 64K RAM Bit 0 error
2 - 1 - 2	Low 64K RAM Bit 1 error
2 - 1 - 3	Low 64K RAM Bit 2 error
2 - 1 - 4	Low 64K RAM Bit 3 error
2 - 2 - 1	Low 64K RAM Bit 4 error
2 - 2 - 2	Low 64K RAM Bit 5 error
2 - 2 - 3	Low 64K RAM Bit 6 error
2 - 2 - 4	Low 64K RAM Bit 7 error
2 - 3 - 1	Low 64K RAM Bit 8 error
2 - 3 - 2	Low 64K RAM Bit 9 error
2 - 3 - 3	Low 64K RAM Bit 10 error
2 - 3 - 4	Low 64K RAM Bit 11 error
2 - 4 - 1	Low 64K RAM Bit 12 error
2 - 4 - 2	Low 64K RAM Bit 13 error
2 - 4 - 3	Low 64K RAM Bit 14 error
2 - 4 - 4	Low 64K RAM Bit 15 error
3 - 1 - 1	DMA #2 register error
3 - 1 - 2	DMA #1 register error
3 - 1 - 3	8259 #1 error
3 - 1 - 4	8259 #2 error
3 - 2 - 4	8042 KB Controller error
3 - 3 - 4	Video Initialization error
3 - 4 - 1	Video retrace failure
3 - 4 - 2	Video Rom-Scan in progress
3 - 4 - 3	Video Rom-Scan Error

3. Diagnostic Beep Codes (cont).

Non-Fatal Errors - (if mfg jumper installed on 8042)

4 - 2 - 1	8253 Timer tick test
4 - 2 - 2	Shutdown/Restart sequence
4 - 2 - 3	Gate A20 failure
4 - 2 - 4	Unexpected Virtual Mode interrupt
4 - 3 - 1	RAM Test in progress
4 - 3 - 3	8253 Timer Channel 2 test
4 - 3 - 4	Time of Day Clock test
4 - 4 - 1	Serial Port test
4 - 4 - 2	Parallel Port test
4 - 4 - 3	Math CoProcessor test

Other:

1 long, 2 short	Can't find video card

4. CPU Summary

Name	Mhz	Mode	Size	Bus	Mfr.	Others	Process
8086	5-10	Real	1MB	16	Intel	Y	NMOS
8088	5-8	Real	1MB	8	Intel	Y	NMOS
80186	8-16	Real	1MB	16	Intel	Y	HMOS
80188	8-16	Real	1MB	8	Intel	Y	HMOS
V20	5-10	Real	1MB	8	NEC	N	CMOS
V30	5-10	Real	1MB	16	NEC	N	CMOS
80286	6-25	R,P	16MB	16	Intel	Y	HMOS
80386SX	16-33	R,P	16Mb	16	Intel	Y	CHMOS
80386DX	16-40	R,P	4Gb	32	Intel	Y	CHMOS
80486SX	16-25	R,P	4Gb	32	Intel	N	CHMOS
80486	25-66	R,P	4Gb	32	Intel	N	CHMOS

5. PC 62 Pin Connector

(Bracket End of Board)

SOLDER SIDE					COMPONENT SIDE
Ground	<	B1	A1	<	-IOCHK
+Reset	<	B2	A2	<>	SD7
+5 Volts	<	B3	A3	<>	SD6
+IRQ2/9	>	B4	A4	<>	SD5
-5 Volts	<	B5	A5	<>	SD4
+DRQ2	>	B6	A6	<>	SD3
-12 Volts	<	B7	A7	<>	SD2
-SRDY	>	B8	A8	<>	SD1
+12 Volts	<	B9	A9	<>	SD0
Ground	<	B10	A10	<	IOCHRDY
-SMEMW	<	B11	A11	>	AEN
-SMEMR	<	B12	A12	<>	SA19
-IOW	<>	B13	A13	<>	SA18
-IOR	<>	B14	A14	<>	SA17
-DACK3	<	B15	A15	<>	SA16
+DRQ3	>	B16	A16	<>	SA15
-DACK1	<	B17	A17	<>	SA14
+DRQ1	>	B18	A18	<>	SA13
-DACK0	<	B19	A19	<>	SA12
CLK	<>	B20	A20	<>	SA11
+IRQ7	>	B21	A21	<>	SA10
+IRQ6	>	B22	A22	<>	SA9
+IRQ5	>	B23	A23	<>	SA8
+IRQ4	>	B24	A24	<>	SA7
+IRQ3	>	B25	A25	<>	SA6
-DACK2	<	B26	A26	<>	SA5
+T/C	<	B27	A27	<>	SA4
+BALE	<	B28	A28	<>	SA3
+5 Volts	<	B29	A29	<>	SA2
OSC	<	B30	A30	<>	SA1
Ground	<	B31	A31	<>	SA0

Notes:

Pin B4 is IRQ2 for an XT

Pin B4 is IRQ9 for an AT which is re-directed as IRQ2

A System Board Jumper on the original IBM AT provided the option of driving the clock (BCLK) signal from an adapter board device. Most clones do not support this option.

6. PC 36 Pin Connector

(this end nearest 62-pin connector)

	-MEMCS16	>	D1	C1	>	SBHE	
	-I/OCS16	>	D2	C2	<>	LA23	
	+IRQ10	>	D3	C3	<>	LA22	C
	+IRQ11	>	D4	C4	<>	LA21	O
S	+IRQ12	>	D5	C5	<>	LA20	M
O	+IRQ15	>	D6	C6	<>	LA19	P
L	+IRQ14	>	D7	C7	<>	LA18	O
D	-DACK0	<	D8	C8	<>	LA17	N
E	+DRQ0	>	D9	C9	>	-MEMR	E
R	-DACK5	<	D10	C10	>	-MEMW	N
	+DRQ5	>	D11	C11	<>	SD08	T
S	-DACK6	<	D12	C12	<>	SD09	
I	+DRQ6	>	D13	C13	<>	SD10	S
D	-DACK7	<	D14	C14	<>	SD11	I
E	+DRQ7	>	D15	C15	<>	SD12	D
	+5 Volts		D16	C16	<>	SD13	E
	-MASTER16	>	D17	C17	<>	SD14	
	Ground		D18	C18	<>	SD15	

Symbols pointing toward the connector designate signals into the system board (from devices on the bus), and vice versa. <> indicates bi-directional signals.

NOTE: In the PC and PC/XT, the bus consists only of the 62-pin portion. Some of the signal names are different, but the functionality remains the same.

7. EISA Pin Assignments

Row F	Row B	Pin No.	Row E	Row A
GND	GND	1	CMD*	IOCHK*
+5V	RESET	2	START*	SD<7>
+5V	+5V	3	EXRDY	SD<6>
XXXXX	IRQ<9>	4	EX32*	SD<5>
XXXXX	-5V	5	GND	SD<4>
KEY	DRQ<2>	6	KEY	SD<3>
XXXXX	-12V	7	EX16*	SD<2>
XXXXX	SRDY*	8	SLBURST*	SD<1>
+12V	+12V	9	MSBURST*	SD<0>
M-IO	GND	10	W-R	IOCHRDY
LOCK*	SMEMW*	11	GND	AENx
RESERVED	SMEMR*	12	RESERVED	SA<19>
GND	IOW*	13	RESERVED	SA<18>
RESERVED	IOR*	14	RESERVED	SA<17>
BE*<3>	DACK*<3>	15	GND	SA<16>
KEY	DRQ<3>	16	KEY	SA<15>
BE*<2>	DACK*<1>	17	BE*<1>	SA<14>
BE*<0>	DRQ<1>	18	LA*<31>	SA<13>
GND	REFRESH*	19	GND	SA<12>
+5V	BCLK	20	LA*<30>	SA<11>
LA*<29>	IRQ<7>	21	LA*<28>	SA<10>
GND	IRQ<6>	22	LA*<27>	SA<9>
LA*<26>	IRQ<5>	23	LA*<25>	SA<8>
LA*<24>	IRQ<4>	24	GND	SA<7>
KEY	IRQ<3>	25	KEY	SA<6>
LA<16>	DACK*<2>	26	LA<15>	SA<5>
LA<14>	TC	27	LA<13>	SA<4>
+5V	BALE	28	LA<12>	SA<3>
+5V	+5V	29	LA<11>	SA<2>
GND	OSC	30	GND	SA<1>
LA<10>	GND	31	LA<9>	SA<0>

Row H	Row D		Row G	Row C
LA<8>	MEMCS16*	1	LA<7>	SBHE*
LA<6>	IOCS16*	2	GND	LA<23>
LA<5>	IRQ<10>	3	LA<4>	LA<22>
+5V	IRQ<11>	4	LA<3>	LA<21>
LA<2>	IRQ<12>	5	GND	LA<20>
KEY	IRQ<15>	6	KEY	LA<19>
DATA<16>	IRQ<14>	7	DATA<17>	LA<18>
DATA<18>	DACK*<0>	8	DATA<19>	LA<17>
GND	DRQ<0>	9	DATA<20>	MEMR*
DATA<21>	DACK*<5>	10	DATA<22>	MEMW*
DATA<23>	DRQ<5>	11	GND	SD<8>
DATA<24>	DACK*<6>	12	DATA<25>	SD<9>
GND	DRQ<6>	13	DATA<26>	SD<10>
DATA<27>	DACK*<7>	14	DATA<28>	SD<11>
KEY	DRQ<7>	15	KEY	SD<12>
DATA<29>	+5V	16	GND	SD<13>
+5V	MASTER16*	17	DATA<30>	SD<14>
+5V	GND	18	DATA<31>	SD<15>
MAKx*		19	MREQx*	

Order of reserved pin assignments: E12, E13, E14, F12, F14
XXXXX pins for manufacturer-specific use. Add-on cards must NOT CONNECT to these pins.

8. ISA/EISA Signal Names

The signal line names have varied between the documentation of the original PC, the XT, AT, the ISA specification, the EISA specification, and between different manufacturers. The following list are the names used in Ed Solari's "ISA & EISA Theory and Operation" (Annabooks). The majority of names match those in the EISA Rev. 3.12 specification. The names listed avoid the use of "-" and "/" to denote an active low signal, using the * as in the EISA specification. Other versions of the signal names are shown in parentheses. Pin number is first of series.

AENx		A11
BALE	(ALE)	B28
BCLK	(CLK)	B20
BE*		F18
CMD*		E1
DACKx*	(DACK*, DAKx*)	B8
DRQx		B9
EX16*		E7
EX32*		E4
EXRDY		E3
IOCHK*	(IOCHCK*, I/OCHCK*)	A1
IOCHRDY	(CHRDY, I/OCHRDY)	A10
IOCS16*	(IO16*, I/OCS16*)	D2
IOR*	(IORC*)	B14
IOW*	(IOWC*)	B13
IRQx		B25
LA* & LA		F5
LOCK*		F11
M-IO	(M-I/O)	F10
MAKx*	(MACKx*)	H19
MASTER16*	(MASTER)	D17
MEMCS16*	(M16*)	D1
MEMR*	(MRDC*)	A9
MEMW*	(MWTC*)	A10
MREQx*		E19
MSBURST*	(MBURST*)	E9
OSC		B30
REFRESH*	(REF*, old DACK<0>)	B19
RESET	(RESDRV, RESETDRV)	B2
SA	(A)	A31
SBHE*		C1
SD	(D, DATA)	A9
SLBURST*	(SBURST*)	E8
SMEMR*	(SMRDC*)	B12
SMEMW*	(SMWTC*)	B11
SRDY*	(NOWS*, 0WS*)	B8
START*		E2
TC	(T-C, T/C)	B27
W-R	(W/R)	E10

9. Bus Signal Summary

Since the XT and AT (ISA) busses are subsets of the EISA bus, this section has been changed to use the EISA set of signal names described in the preceeding section. Please also see the preceeding section for some of the alternative or older names for some of the lines. The Descriptions below are brief by necessity; designers should refer to other sources, such as "ISA & EISA Theory and Operation" (Annabooks) for more details.

Name	Description
AENx	Address Enable. Indicates DMA controller is bus master (ISA). Also used by EISA for slot-specific I/O addressing (x = slot number).
BALE	Bus Latch Enable. Indicates that SA, LA, AENx, and SBHE* signal lines are valid.
BCLK	Bus Clock. 4.77 MHz 33% duty cycle on PC and XT. 50% duty cycle 6 MHz for AT, and 8 or 8.33 MHz for EISA. 4.0 MHz minimum for EISA.
BE*<0-3>	Byte Enable. Indicates which byte lanes are valid. EISA only.
CMD*	Command. Controls cycle timing after active START* signal. EISA only.
DACKx*	DMA Acknowledge. Used by DMA controller to select an I/O resource that requested the bus (DRQx). Used by ISA bus master to gain control of the bus from DMA controller. DACK<0> used by XT and AT computers for memory refresh.
DRQx	DMA Request. Used by I/O resources to request DMA service. Must be held high until associated DACKx* line is active.
EX16* EX32*	EISA Access 16 or 32 data bit. Indicates data width of an EISA resource. Also driven by platform circuitry to indicate completion of certain cycles.
EXRDY	EISA Access Ready. Driven by EISA resource to indicate additional cycle time is required.
IOCHK*	I/O Channel Check. Driven by any resource to indicate a bus error, such as parity. Only serviced by platform circuitry. Usually sends NMI to CPU.

9. Bus Signal Summary (cont.)

IOCHRDY	I/O Channel Ready. Driven inactive by a bus resource that needs additional cycles. Must not be held inactive for more than 15.6 usec or refresh may be missed.
IOCS16*	I/O Chip Select 16. Indicates that a resource supports 16 bit accesses. Ignored by DMA and refresh controllers.
IOR* IOW*	I/O Read (Write). Used by ISA & EISA bus master or DMA controller to request non-EISA I/O resource to drive data (or read data) on data lines. Not defined for EISA bus master and EISA I/O resources. (See M-IO and W-R.)
IRQx	Interrupt Request. Used by add-on card to request service by platform. Edge-triggered (ISA) allows one card per line. Level triggered option (EISA) allows sharing.
LA<2-16>	Latchable Address. LA<2-16> (EISA only) are latchable address lines. Must be latched by the resource if they are required for the entire cycle. See SA for ISA.
LA<17-23>	Same, except they appear on the 16 bit part of the ISA connector.
LA*<24-31>	Highest byte of the 32 bit (EISA) latchable address bus. Same function as LA except for inverted logic.
LOCK*	Lock. Insures exclusive memory or I/O access by the EISA bus master that drives it active. Cannot be used during DMA transfer cycles or during certain other cycles.
M-IO	Memory-I/O. Defines memory cycle (high) or I/O cycle (low). EISA only.
MAKx*	Master Acknowledge. Used by EISA platform arbiter to award bus master in response to a request (see MREQx*). EISA only.
MASTER16*	Master 16 bit. Used by add-on bus master to indicate 16 bit data size. With EISA platform and add-on bus master, non-assertion indicates 32 bit bus master.

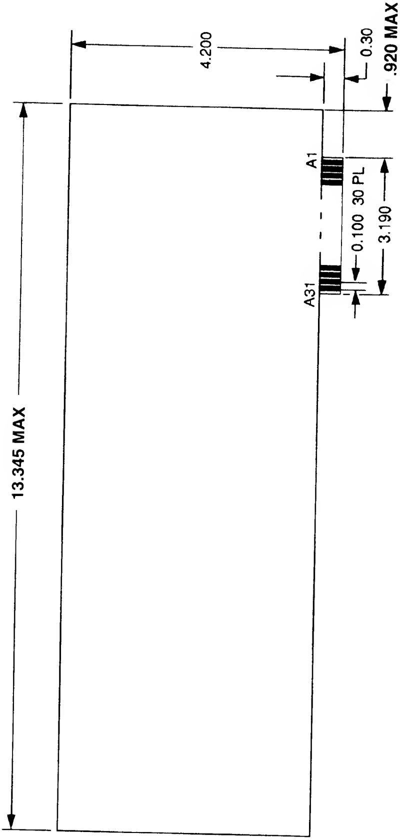
9. **Bus Signal Summary** (cont.)

MEMCS16*	Memory Chip Select 16. Driven by memory resource to indicate support of 16 bit accesses. Also allows bus master to execute shorter cycles. Bus master must ignore this line during I/O access cycles. Also ignored by DMA and refresh controllers. Not defined when EISA bus master accessing EISA resource.
MEMR* MEMW*	Memory Read (Write). Used by the bus owner to request a memory resource to drive (accept) data. See also SMEMR* and SMEMW*.
MREQx*	Master Request. Used by EISA add-on card (in slot x) to request bus ownership. See also MAKx.
MSBURST*	Master Burst. Used by EISA bus owner to notify accessed resource that it will execute a burst access cycle. Burst access cycle occurs only if both MSBURST* and SLBURST* are active.
NOWS*	See SRDY*.
OSC	Oscillator. A 50% duty cycle clock at 14.31818 MHz. Used originally for color burst in composite video. Not synchronized to any other signal.
REFRESH*	Memory Refresh. Indicates a refresh cycle is in progress. Memory is refreshed every 15.6 usec.
RESET	Used to reset or initialize system logic on power up, during low line voltage, or after a bus timeout. EISA systems allow software to issue reset by setting bit 0 of I/O port 0461h to a "1". Setting the bit to a "0" negates command.
SA	System Address. Address lines for the first one megabyte of memory. SA<0-9> used for I/O addresses. SA<0> is the least significant bit.
SBHE*	System Byte High Enable. Indicates valid data on SD<8-15> lines. Inactive indicates 8 bit data width. Not used when EISA bus master accesses EISA resources.
SD	System Data. SD<0> is the least significant bit. Platform byte swapper circuitry assures SD<8-15> valid when SBHE* is active.

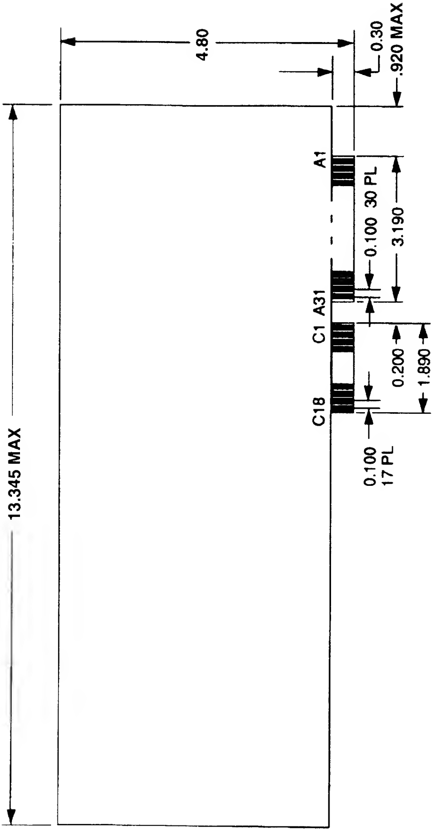
9. **Bus Signal Summary** (cont.)

SLBURST*	Slave Burst. An EISA slave asserts this line to indicate that it can support a burst access cycle. See also MSBURST*.
SMEMR* SMEMW*	System Memory Read (Write). Requests a memory resource to drive (accept) data. Purpose is to maintain compatiblilty with 8 bit add-on cards. Derived from MEMR* (or MEMW*) and LA<20-23>, so timing lags.
SRDY* (NOWS*)	Synchronous Ready (NO Wait State). Asserted by accessed resource to indicate that a shorter access cycle can be executed.
START*	Indicates the beginning of an EISA access cycle and the initial qualification of other signal lines.
TC	Terminal Count. Driven by the DMA contoller to indicate completion of data transfer. Can be bi-directional for EISA.
W-R	Write (high) - Read (low). Indicates to accessed resource whether to accept data or drive data. May be driven by the bus master, refresh controller, DMA controller, or platform circuitry depending on the cycle. EISA only.

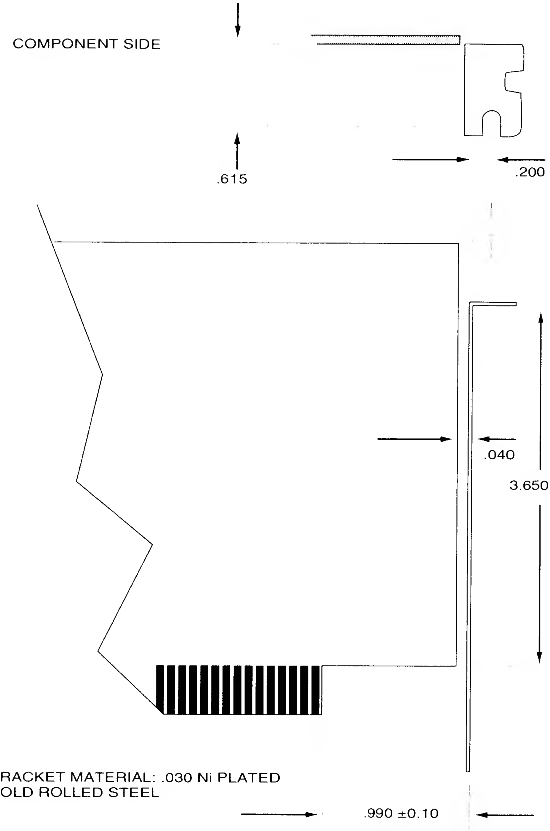
10. XT Add-On Card Dimensions



11. AT Add-On Card Dimensions

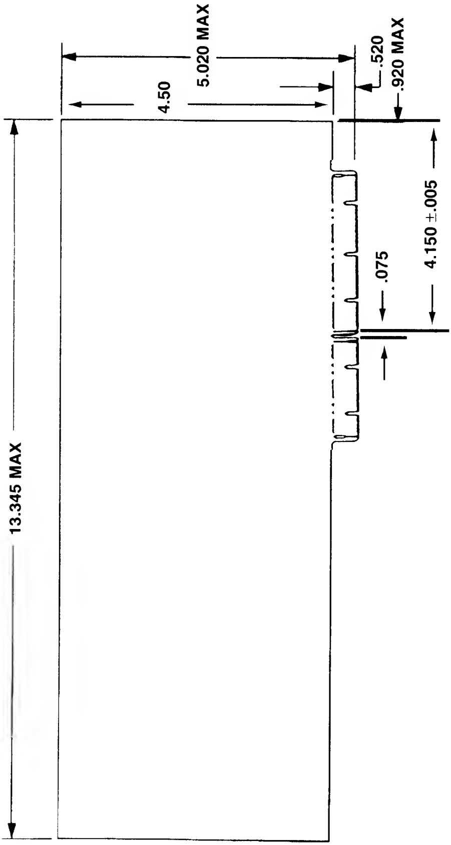


12. Card Bracket Position



BRACKET MATERIAL: .030 Ni PLATED
COLD ROLLED STEEL

13. EISA Add-On Card Dimensions



14. Power Cables

PS-8

Connector: 6-pin Molex

1	Pwr Good
2	+5v
3	+12v
4	-12v
5	gnd
6	gnd

PS-9

Connector: 6-pin Molex

1	gnd	gnd
2	gnd	gnd
3	-5v	-5v
4	+5v	+5v
5	+5v	+5v
6	+5v	+5v

Disk drive power

Connector: 4-pin Molex

1	+12v
2	gnd
3	gnd
4	+5v

AT Battery connector

Connector: 4-pin Berg

1	gnd
2	unused
3	key
4	+6v

AT LED and Keylock connector

Connector: 5-pin Berg

1	LED Power (+5v)
2	key
3	Gnd
4	Keyboard inhibit
5	Gnd

15. Display Cables

MDA (Hercules) Display:
Connector: Female 9-Pin D-Sub, cable requires male.

Pin	I/O	Description
1		Ground
2		Ground
3		Not Used
4		Not Used
5		Not Used
6	>	+Intensity
7	>	+Video
8	>	+Horizontal
9	>	-Vertical

CGA Display:
Connector: Female 9-Pin D-Sub, cable requires male.

Pin	I/O	Description
1		Ground
2		Ground
3	>	Red
4	>	Green
5	>	Blue
6	>	Intensity
7	>	Reserved
8	>	Horizontal Drive
9	>	Vertical Drive

EGA RGB Display:
Connector: Female 9-Pin D-Sub, cable requires male.

Pin	I/O	Description
1		Ground
2	>	S. red
3	>	Red
4	>	Green
5	>	Blue
6	>	S. green/Intensity
7	>	S. blue/mono video
8	>	Horizontal Drive
9	>	Vertical Drive

15. Display Cables (cont.)

VGA RGB Display:

Connector: Female 15-Pin D-Sub, cable requires male.

Pin	I/O	Descr.	Mono Use	Color Use
1	>	Red		Red
2	>	Green	Mono	Green
3	>	Blue		Blue
4		reserved		
5		Digital Gnd	Self Test	Self Test
6	<	Red return	Key	R. return
7	<	Grn return	Mono return	G. return
8	<	Blue return		B. return
9		Plug		
10		Digital Gnd	Gnd	Gnd
11		reserved		Gnd
12		reserved		Gnd
13	>	H. Drive	H. Drive	H. Drive
14	>	V. Drive	V. Drive	V. Drive
15		reserved		

CGA Composite Video:

Connector: RCA phono jack, cable requires male

Pin	I/O	Description
1	<	(Pin) 1.5Vdc Composite video
2	<	(Shell) Ground

16. XT Speaker Cable Connector

Connector 4-pin Berg

Pin	Name
1	Audio
2	key
3	Gnd
4	+5v

17. Keyboard Cable

Connector: 5-Pin DIN Female, cable requires male.

Pin	Name
1	+Keyboard Clock
2	+Keyboard Data
3	-Keyboard Reset
4	Ground
5	+5 Volts

18. Parallel Printer Cable

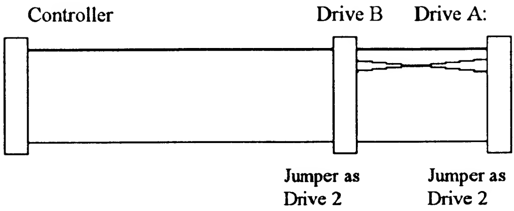
PC (D-25 male) --Prn (Amphenol 57-30360 male)

Description	PC-Pin	Direct.	Prn-Pin
-Strobe	1	<>	1
+Data Bit 0	2	<>	2
+Data Bit 1	3	<>	3
+Data Bit 2	4	<>	4
+Data Bit 3	5	<>	5
+Data Bit 4	6	<>	6
+Data Bit 5	7	<>	7
+Data Bit 6	8	<>	8
+Data Bit 7	9	<>	9
-Acknowledge	10	<	10
+Busy	11	<	11
+Paper End	12	<	12
+Select	13	<	13
-Auto Feed	14	>	14
-Error/Fault	15	<	32
-Printer Init	16	>	31
-Select	17	>	36
Ground	18		-
Ground	19		19
Ground	20		20
Ground	21		21
Ground	22		22
Ground	23		23
Ground	24		24
Ground	25		25
Ground			26
Ground			27
Ground			28
Ground			29
Ground			30
-Printer Init	16	>	31
-Error/Fault	15	<	32
Ground			33
Not Used			34
+5v through 4.7K			35
-Select	17	<	36

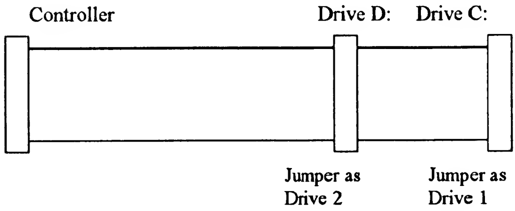
19. Disk Cables

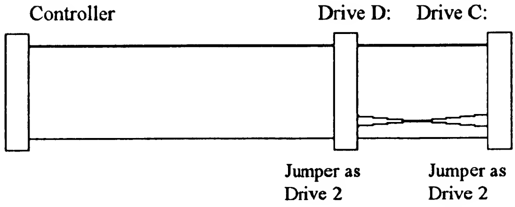
The 34-conducter Disk Cables have three variations. The types and applicability of each is shown below:

Floppy Drives



Hard Drives





20. RS-232C Cables

Serial Adapter Connector: Male 25-Pin D-Sub

Pin	I/O	Description
1		NC (Shield Gnd. Other End)
2	>	TX (Transmit Data)
3	<	RX (Receive Data)
4	>	RTS (Request to Send)
5	<	CTS (Clear to Send)
6	<	DSR (Data Set Ready)
7		GND (Signal Ground)
8	<	DCD (Data Carrier Detect)
9	>	+Transmit Current Loop Data
10		NC
11	>	-Transmit Current Loop Data
12		NC
...		NC
17		NC
18	<	+Receive Current Loop Data
19		NC
20	>	DTR (Data Terminal Ready)
21		NC
22	<	RI (Ring Indicator)
23		NC
24		NC
25	<	-Receive Current Loop Data

Alternate Adapter Connector: Male 9-Pin D-Sub

Pin	I/O	Description
1	<	DCD (Data Carrier Detect)
2	<	RX (Receive Data)
3	>	TX (Transmit Data)
4	>	DTR (Data Terminal Ready)
5		GND (Signal Ground)
6	<	DSR (Data Set Ready)
7	>	RTS (Request To Send)
8	<	CTS (Clear To Send)
9	<	RI (Ring Indicator)

20. RS-232C Cables (cont.)

To wire a 25-pin connector to a 9-pin connector, use the following table:

DB-9	DB-25	Description
1	8	DCD (Data Carrier Detect)
2	3	RX (Receive Data)
3	2	TX (Transmit Data)
4	20	DTR (Data Terminal Ready)
5	7	GND (Signal Ground)
6	6	DSR (Data Set Ready)
7	4	RTS (Request To Send)
8	5	CTS (Clear To Send)
9	22	RI (Ring Indicator)

21. Game Controller Adapter Cable

Connector: Female 15-Pin D-Sub, cable requires male.

Pin	I/O	Description
1	>	+5 Volts
2	<	Button 4
3	<	Position 0
4		Ground
5		Ground
6	<	Position 1
7	<	Button 5
8	>	+5 Volts
9	>	+5 Volts
10	<	Button 6
11	<	Position 2
12		Ground
13	<	Position 3
14	<	Button 7
15	>	+5 Volts

22. Memory Map

Hex Address Range		Usage
00000-9FFFF	(640K)	System DRAM
00000-001DF	(480)	Interrupt Vectors
001E0-002FF	(288)	User Vectors
00300-003FF	(256)	Bios Stack/User Vectors
00400-004FF	(256)	Bios Data
00500-005FF	(256)	DOS and Basic Use
00600-9FFFF	(638K)	User Ram
A0000-BFFFF	(128K)	Video Buffer RAM Area
A0000-BFFFF	(128K)	EGA/VGA Video Buffer
B0000-B7FFF	(32K)	MDA Video Buffer
B8000-BFFFF	(32K)	CGA Video Buffer
C0000-DFFFF	(128K)	Rom Expansion Area
C0000-C3FFF	(16K)	EGA Bios
C6000-C63FF	(1K)	PGA Comm Area
C8000-CBFFF	(16K)	XT Hard Disk Bios
D0000-D7FFF	(32K)	Cluster Adapter Bios
E0000-EFFFF	(64K)	Rom Expansion (XT) Bios Expansion (AT)
F0000-FFFFF	(64K)	BIOS
100000-FDFFFF	(14.9MB)	AT Extended RAM
FE0000-FFFFFF	(128K)	AT Rom Bios Area

23. I/O Map

Hex Range	Usage
000-00F	8237 DMA #1
020-021	8259 PIC #1
040-043	8253 Timer
060-063	8255 PPI (XT)
060-064	8742 Controller (AT)
070-071	CMOS RAM & NMI Mask Reg (AT)
080-08F	DMA Page Registers
0A0-0A1	8259 PIC #2 (AT)
0A0-0AF	NMI Mask Register (XT)
0C0-0DF	8237 DMA #2 (AT - word mapped)
0F0-0FF	80287 Numeric Processor (AT)
1F0-1FF	Hard Disk (AT)
200-20F	Game/Control
210-21F	Expansion Unit (XT)
238-23B	Bus Mouse
23C-23F	Alt. Bus Mouse
278-27F	Parallel Printer
2B0-2BF	EGA
2C0-2CF	EGA
2D0-2DF	EGA
2E0-2E7	GPIB (AT)
2E8-2EF	Serial Port
2F8-2FF	Serial Port
300-30F	Prototype Card
310-31F	Prototype Card
320-32F	Hard Disk (XT)
378-37F	Parallel Printer
380-38F	SDLC
3A0-3AF	SDLC
3B0-3BB	MDA
3BC-3BF	Parallel Printer
3C0-3CF	EGA
3D0-3DF	CGA
3E8-3EF	Serial Port
3F0-3F7	Floppy Disk
3F8-3FF	Serial Port

Due to the wide variety of third-party adapters available for the PC-Bus, the installation of adapters using ports not listed above may result in conflicting assignments. Users are cautioned that problems usually occur if ports collide.

24. BIOS Data Area

The Bios Data area is located at 0040:0000 - 0040:00FF. The actual use of this area may vary. The table below shows the typical usage. Locations shown as "not used" or "reserved" may in fact be used in some instances.

Loc.	Size	Description
00	word	COM1 port address
02	word	COM2 port address
04	word	COM3 port address
06	word	COM4 port address
08	word	LPT1 port address
0A	word	LPT2 port address
0C	word	LPT3 port address
0E	word	Extended Bios Data Pointer
10	word	equipment variable
12	byte	not used
13	word	memory size in 1K blocks
15	word	not used
17	byte	keyboard flag 1
18	byte	keyboard flag2
19	byte	ALT-keypad buffer
1A	word	keyboard buffer head
1C	word	keyboard buffer tail
1E	16 words	keyboard buffer
3E	byte	floppy recalibrate flag
3F	byte	floppy motor status
40	byte	floppy motor off counter
41	byte	floppy status byte
42	7 bytes	floppy controller status bytes
49	byte	display mode
4A	word	display number of columns
4C	word	video buffer length (bytes)
50	8 words	cursor position (8 pages)
60	word	cursor type
62	byte	active display page
63	word	video controller port address
65	byte	current 3x8 register value
66	byte	current 3x9 register value
67	dword	virtual save for segment:offset
6B	byte	virtual mode flag
6C	dword	timer counter
70	byte	timer overflow flag
71	byte	break key flag
72	word	reset flag (1234H = warm boot)

24. BIOS Data Area (cont.)

Loc.	Size	Description
74	byte	hard disk status
75	byte	number of hard drives
76	byte	XT hard disk control byte
77	byte	XT hard disk controller port
78	byte	LPT1 timeout value
79	byte	LPT2 timeout value
7A	byte	LPT3 timeout value
7B	byte	not used
7C	byte	COM1 timeout value
7D	byte	COM2 timeout value
7E	byte	COM3 timeout value
7F	byte	COM4 timeout value
80	word	keyboard buffer start pointer
82	word	keyboard buffer end pointer
84	byte	number of video rows (-1)
85	word	char height in bytes/char
87	byte	video control state 1
88	byte	video control state 2
89	word	not used
8B	byte	floppy data and step rates
8C	byte	hard disk controller status
8D	byte	hard disk error status
8E	byte	hard disk interrupt control
8F	byte	not used
90	byte	floppy drive 0 media state
91	byte	floppy drive 1 media state
92	word	not used
94	byte	floppy drive 0 current cylinder
95	byte	floppy drive 1 current cylinder
96	byte	keyboard flag 3
97	byte	keyboard LED flags
98	dword	vector to user wait flag
9C	dword	user wait count
A0	byte	wait active flag
A1	7 bytes	reserved
A8	dword	EGA parameter table pointer
AC	dword	EGA save area 1 pointer
B0	dword	EGA alpha font pointer
B4	dword	EGA graphics font pointer
B8	dword	PS/2 save area 2 pointer
BC	72 bytes	reserved

0050:0000 is the print_screen status byte

25. Interrupt Map

No.	Addr	Type	Description
0	00	CPU	Divide by Zero
1	04	CPU	Single Step
		386	Debug Exception
2	08	CPU	NMI
3	0C	CPU	Breakpoint
4	10	CPU	Overflow
5	14	Bios	Print Screen
		186	Bounds Fault Exception
6	18	186	Invalid Opcode
7	1C	186	NPX unavailable
8	20	Bios	IRQ0 - Time of Day
		286	LIDT or Double Fault
9	24	Bios	IRQ1 - Keyboard
		286	NPX segment
A	28	Bios	IRQ2 - Reserved
		286	Invalid TSS
B	2C	Bios	IRQ3 - COM
		286	Segment not present
C	30	Bios	IRQ4 - COM
		286	Stack Fault Exception
D	34	Bios	IRQ5 - XT-Hard Disk, AT-LPT
		286	Protection Fault
E	38	Bios	IRQ6 - Floppy Disk
		386	Page Fault
F	3C	Bios	IRQ7 - LPT
10	40	Bios	Video Driver
		286	NPX Error
11	44	Bios	Equipment Check
		486	Alignment Check
12	48	Bios	Memory Size
13	4C	Bios	Disk Driver
14	50	Bios	Serial Driver
15	54	Bios	Cassette Driver
16	58	Bios	Keyboard Driver
17	5C	Bios	Printer Driver
18	60	Bios	BASIC (SysVue)
19	64	Bios	Bootstrap
1A	68	Bios	Time of Day
1B	6C	Bios	Keyboard Break
1C	70	Bios	Timer Tick
1D	74	Bios	Video Initialization
1E	78	Bios	Diskette Parm Table
1F	7C	Bios	CGA Graphics Font
20	80	DOS	Program Terminate
21	84	DOS	Function Call

25. **Interrupt Map** (cont.)

No.	Addr	Type	Description
22	88	DOS	Terminate Address
23	8C	DOS	Ctrl-Brk Exit Address
24	90	DOS	Fatal Error Vector
25	94	DOS	Absolute Disk Read
26	98	DOS	Absolute Disk Write
27	9C	DOS	Terminate
28	A0	DOS	Idle Signal
29	A4	DOS	TTY Output
2A	A8	DOS	MS-Net services
2F	BC	DOS	Print Spool
30	C0	DOS	Long Jump interface
33	CC	DOS	Mouse Functions
3F	FC	DOS	Overlay Interrupt
40	100	Bios	Hard Disk Chain
41	104	Bios	Disk #1 Parm Table
42	108	Bios	EGA Chain
43	10C	Bios	EGA Parm Table Ptr
44	110	Bios	EGA Graphics Font
46	118	Bios	Disk #2 Parm Table
4A	128	Bios	AT Alarm Exit Address
50	140	Bios	AT Alarm Interrupt
51	144	Bios	Mouse Functions
5A	168	NET	Functions
5B	16C	NET	Boot Chain
5C	170	NET	NetBios entry
67	19C	DOS	EMS Functions
6D	1B4	VGA	Suspected VGA Service
70	1C0	ATBios	IRQ8 - Real-Time Clock
71	1C4	ATBios	IRQ9 - Re-directed to IRQ2
72	1C8	ATBios	IRQ10 - Unassigned
73	1CC	ATBios	IRQ11 - Unassigned
74	1D0	ATBios	IRQ12 - Unassigned
75	1D4	ATBios	IRQ13 - 80287 NPX
76	1D8	ATBios	IRQ14 - AT Hard Disk
77	1DC	ATBios	IRQ15 - Unassigned
80	200	BASIC	
|			
F0	3C0	BASIC	
F1	3C4	---	Not Used
|			
FF	3FC	---	Not Used

26. Hardware Interrupts

Name	Int#	Description
NMI	---	Parity*
0	8	Timer*
1	9	Keyboard*
IRQ2	A	Reserved (XT), Int. 8-15 (AT)
IRQ3	B	COM or SDLC
IRQ4	C	COM or SDLC
IRQ5	D	Hard Disk (XT), LPT (AT)
IRQ6	E	Floppy Disk
IRQ7	F	LPT

(Following are AT only)

Name	Int#	Description
IRQ8	70	Real-Time Clock
IRQ9	71	Re-directed to IRQ2
IRQ10	72	Unassigned
IRQ11	73	Unassigned
IRQ12	74	Unassigned
IRQ13	75	80287 Co-processor
IRQ14	76	Hard Disk
IRQ15	77	Unassigned

*These interrupts exist on the system board and are not available on the Bus Connector.

27. DMA Channels

Channel	Usage
0	Memory Refresh
1	SDLC
2	Floppy Disk
3	Unassigned
4	Unassigned
5	Unassigned
6	Unassigned
7	Unassigned

Channels 0-3 (DMA #1) are 8 bit channels (XT & AT).
Channels 4-7 (DMA #2) are 16 bit channels (AT only).

28. BIOS Entry Points

IBM warns programmers not to use the actual entry points for the various BIOS routines, as they may change from version to version. The proper entry to the BIOS is through the software interrupt system. In practice, however, usually in the interest of maximizing speed, there are those who violate the rule. The following entry points have remained constant on all or nearly all of the PC and XT-compatible BIOS versions. Be aware of the risk to future compatibility if your software uses them.

Address	Name
F000:E05B	Reset
F000:E2C3	NMI Entry Point
F000:E6F2	Bootstrap Load
F000:E729	UART Parms for Overlaying Drivers
F000:E739	Comm Function Call
F000:E82E	Keyboard Function Call
F000:E987	Keyboard Hardware Interrupt
F000:EC59	Floppy Disk Function Call
F000:EF57	Floppy Disk ISR
F000:EFC7	Floppy Disk Parameter Table
F000:EFD2	LPT Function Call
F000:F065	Video Function Call
F000:F0A4	Video 6845 Parameters
F000:F841	Memory Size Function Call
F000:F84D	Equipment Check Function Call
F000:F859	Cassette Function Call
F000:FA6E	Video Char. Font-Graphics Mode
F000:FE6E	Timer Function Call
F000:FEA5	Timer Hardware Interrupt
F000:FEF3	Interrupt Vector Table
F000:FF53	Dummy Interrupt Return
F000:FF54	Print Screen Function Call
F000:FFF0	Hardware Reset Point
F000:FFF5	Date Stamp of BIOS
F000:FFFE	Hardware ID Byte (Model Number)

FF = PC
FE = XT and Portable PC
FD = PCjr
FC = AT
FB = XT After 1-10-86
FA = PS/2 Model 30
F9 = PC Convertible
F8 = PS/2 Model 80

29. AT Hard Drive Types

Caution:

The first fifteen drive types were defined by IBM in the original AT. Since then, additional types have been defined by IBM and others, so that the table in your machine may vary! If you install a different Bios in an AT type machine and have difficulty booting, print out or inspect the drive tables to insure that the correct type is selected. The address of the drive table can be found at location 0000:0118 - 0000:011B when only 1 Hard Drive is selected during the configuration "Setup" routine. This location may not be valid if 2 Hard Drives are selected.

(AT BiosKit - The Drive Table may be displayed with the SysVue "TYPES" Command).

In the following table, these abbreviations are used:
Typ = Drive type number
Cyl = Number of cylinders
Hds = Number of heads
Cmp= Pre-compensation
Zon = Landing zone
Sec = Number of sectors
Mb = Approximate number of megabytes

Type	Cyl	Hds	Cmp	Zone	Sec	Mb
1	306	4	128	305	17	10
2	615	4	300	615	17	20
3	615	6	300	615	17	32
4	940	8	512	940	17	64
5	940	6	512	940	17	48
6	615	4	-1	615	17	20
7	462	8	256	511	17	30
8	733	5	-1	733	17	30
9	900	15	-1	901	17	110
10	820	3	-1	820	17	20
11	855	5	-1	855	17	35
12	855	7	-1	855	17	50
13	306	8	128	319	17	20
14	733	7	-1	733	17	40
15	0	0	0	0	0	0

29. AT Hard Drive Types (cont.)

Note: The following definitions may vary.

Type	Cyl	Hds	Cmp	Zone	Sec	Mb
16	612	4	0	663	17	20
17	977	5	300	977	17	40
18	977	7	-1	977	17	56
19	1024	7	512	1023	17	60
20	733	5	300	732	17	30
21	733	7	300	733	17	42
22	733	5	300	733	17	30
23	306	4	0	336	17	10
24	925	7	0	925	17	53
25	925	9	0	925	17	70
26	754	7	0	754	17	43
27	754	11	0	754	17	68
28	699	7	0	699	17	40
29	823	10	0	823	17	68
30	918	7	0	918	17	53
31	1024	11	0	1024	17	93
32	1024	15	0	1024	17	127
33	1024	5	0	1024	17	42
34	612	2	0	611	17	10
35	1024	9	0	1024	17	76
36	1024	8	0	1024	17	68
37	615	8	0	615	17	40
38	987	3	0	987	17	24
39	987	7	0	987	17	57
40	820	6	0	820	17	40
41	977	4	0	977	17	32
42	981	4	0	981	17	32
43	830	7	0	830	17	48
44	830	10	0	830	17	68
45	612	4	305	663	17	20
46	306	4	-1	340	17	10
47	612	4	-1	670	17	20
48	698	7	300	732	17	40
49	976	5	488	977	17	40
50	306	4	0	340	17	10
51	611	4	306	663	17	20
52	732	7	300	732	17	42
53	1023	5	-1	1023	17	42
54	306	2	-1	305	17	5
55	1024	8	512	1024	17	68

30. AT CMOS Memory

Real time clock is BCD values in locations 00-0D.

00	Seconds
01	Seconds Alarm
02	Minutes
03	Minutes Alarm
04	Hours
05	Hours Alarm
06	Day of Week
07	Day of Month
08	Month
09	Year

0A Bit 7 - Update in Progress

0E is the Diagnostic Status Byte:
Bit 7 - Chip lost power
Bit 6 - Bad checksum
Bit 5 - Bad configuration byte
Bit 4 - Bad memory size
Bit 3 - Bad hard disk byte
Bit 2 - Bad time of day

0F is the restart status byte. It is loaded before doing a re-start of the 80286, such as when returning from protected mode.

10 designates the floppy disk drive type:

Bits 7-4	Drive A:
Bits 3-0	Drive B:
0	No drive
1	360K drive
2	1.2 MB drive
3	720K drive
4	1.44 MB drive

12 is the hard disk drive type:

Bits 7-4	1st Hard Drive
Bits 3-0	2nd Hard Drive
0	No drive
1-E	Type 1-15
F	Use contents of byte 19 or 1A.

30. AT CMOS Memory (cont.)

14 is the equipment byte:
Bits 7-6: 00 = 1 Floppy
01 2 Floppies
10 3 Floppies (AT BiosKit)
11 4 Floppies (AT BiosKit)
Bits 5-4: 00 = EGA/VGA
01 CGA 40 x 25
10 CGA 80 x 25
11 MDA

Bit 1: 80287 installed
Bit 0: Floppy drive(s) present

15-16 are the memory size below 1MB (preset by setup program)
17-18 are the memory size above 1MB (preset by setup program)

19 1st Hard Disk type when 12(Bits 7-4) = type F

1A 2nd Hard Disk type when 12(Bits 3-0) = type F

2E-2F are the checksum for bytes 10-2D.

30-31 indicate the memory size above 1MB as determined by power-up routines.

32 is the BCD century byte

33 indicates the power-on information flags:
Bit 7 Top 128K of RAM is installed (shadow RAM is available).
Bit 6 First bootup after running setup routine.

To read or write to the AT's CMOS memory:
Output cell address to I/O port 70.
Read/Write data from/to I/O port 71.

31. Switch Settings

This section applies only to the PC and XT

Number of Drives:

	Switch 1	
	Section 7	Section 8
One	On	On
Two	Off	On
Three	On	Off
Four	Off	Off

Monitor Type:

	Switch 1	
	Section 5	Section 6
EGA	On	On
CGA 40x25	Off	On
CGA 80x25	On	Off
MDA or Both	Off	Off

8087 Math Co-Processor Present:

Switch 1
Section 2
On

Memory on System Board:

		Switch 1	
PC	XT	Section 3	Section 4
16K	64K	On	On
32K	128K	Off	On
48K	192K	On	Off
64K	256K	Off	Off

Memory on Expansion Bus (PC):

	Switch 2			
Sections	1	2	3	4
96K	Off	On	On	On
128K	On	Off	On	On
160K	Off	Off	On	On
192K	On	On	Off	On
224K	Off	On	Off	On
256K	On	Off	Off	On
288K	Off	Off	Off	On
320K	On	On	On	Off
352K	Off	On	On	Off
384K	On	Off	On	Off
416K	Off	Off	On	Off
448K	On	On	Off	Off
480K	Off	On	Off	Off
512K	On	Off	Off	Off
544K	Off	Off	Off	Off

32. Video

CGA Board:

3D4 6845 Address Register
3D5 6845 Data Register
3D8 Control Register-Write
- Bit 5 - Background Intensity/Blink Selector
- Bit 4 - Disable/Enable 640 x 200 B/W Mode
- Bit 3 - Disable/Enable Video
- Bit 2 - Color/B/W Mode
- Bit 1 - Text/Graphics Mode
- Bit 0 - 40 x 25/80 x 25 Mode

3D9 Color Select Register-Write
- Bit 7 - Not used
- Bit 6 - Not used
- Bit 5 - Active Color Set (320x200)
- Bit 4 - Intensified
  - Alternate Color Set (Graphics)
  - Background Colors (Alphanumeric)
- Bit 3 - Selects Intensified:
  - Border Color (40x25)
  - Background Color (320x200)
  - Foreground Color (640x200)
- Bit 2 - Selects Red:
  - Border Color (40x25)
  - Background Color (320x200)
  - Foreground Color (640x200)
- Bit 1 - Selects Green:
  - Border Color (40x25)
  - Background Color (320x200)
  - Foreground Color (640x200)
- Bit 0 - Selects Blue:
  - Border Color (40x25)
  - Background Color (320x200)
  - Foreground Color (640x200)

3DA Status Register-Read
- Bit 3 - Vertical Sync
- Bit 2 - Light Pen Switch
- Bit 1 - Light Pen Trigger Armed
- Bit 0 - Display Enable

Buffer at B8000

32. Video (cont.)

EGA Board:

3C0	ATC Index register
3C2	Input Status register 0
3C4	TS Index Register
3C5	TS Data Register
3CA	Graphics position register 2
3CC	Graphics position register 1
3CE	GDC index register
3CF	GDC data register
3B4-3D4	CRTC index register
3B5-3D5	CRTC data register
3BA-3DA	Input status register 1

Buffer at A0000

VGA Board:

3C0	RW	Address register
3C0	W	Attribute register
3C1	R	Attribute register
3C2	R	Input Status register 0
3C2	W	Misc. output
3C3	RW	Video subsystem enable
3C4	RW	Address register
3C5	RW	Sequence register
3C6	RW	PEL mask register
3C7	RW	PEL address read mode
3C7	R	DAC state register
3C8	RW	PEL address write mode
3C9	RW	PEL data register
3CA	R	Feature control register
3CC	R	Misc output
3CE	RW	Address register
3CF	RW	Graphics register
3B4-3D4	W	CRTC index
3B5-3D5	RW	CRTC data
3BA-3DA	R	Input Status register 1
3BA-3DA	W	Feature Control register

Buffer at A0000

MDA Board:

3B4	6845 Address Register
3B5	6845 Data Register
3B8	Control Register-Write Bit 5 - Disable/Enable Blink Bit 3 - Disable/Enable Video Bit 0 - High Res. Mode
3BA	Status Register-Read Bit 7 - Vertical Sync Bit 3 - Video Bit 0 - Horizontal Sync

Buffer at B0000

Programming the 6845 Video Controller for Different Modes: To set up the 6845, the Address Register 3X4 is loaded with the Register #, and the values in the following table are written to 3X5. Each column represents a different mode:

A: 40 x 25 Color-Text
B: 80 x 25 Color-Text
C: 320 x 400 / 640 x 200 Mode for Color Bd.
D: 80 x 25 Monochrome-Text
E: 80 x 25 Mono.-Hercules Graphics

Reg#	A	B	C	D	E
0	38	71	38	61	36
1	28	50	28	50	2D
2	2D	5A	2D	52	2F
3	0A	0A	0A	0F	07
4	1F	1F	7F	19	5B
5	06	06	06	06	00
6	19	19	64	19	57
7	1C	1C	70	19	57
8	02	02	02	02	02
9	07	07	01	0D	03
A	06	06	06	0B	00
B	07	07	07	0C	00
C	00	00	00	00	00
D	00	00	00	00	00

33. 8237 DMA Controller(s)

Controller 1: 8-bit (ports 000-00F)

Page Register	I/O Address
Channel 0	(AT) 087
Channel 1	083
Channel 2	081
Channel 3	082

Controller 2: 16-bit (AT Only - ports 0C0-0DF)

Page Register	I/O Address
Channel 5	08B
Channel 6	089
Channel 7	08A

Refresh (AT)	08F

DMA#		
1	**2**	**Description**
000	0C0	Channel 0/4 Base & Current Address
001	0C2	Channel 0/4 Base & Current Word Count
002	0C4	Channel 1/5 Base & Current Address
003	0C6	Channel 1/5 Base & Current Word Count
004	0C8	Channel 2/6 Base & Current Address
005	0CA	Channel 2/6 Base & Current Word Count
006	0CC	Channel 3/7 Base & Current Address
007	0CE	Channel 3/7 Base & Current Word Count
008	0D0	Read Status/Write Command Register
009	0D2	Write Request Register
00A	0D4	Write Single Mask Register Bit
00B	0D6	Write Mode Register
00C	0D8	Clear Byte Pointer Flip/Flop
00D	0DA	Read Temp Regsiter/Write Master Clear
00E	0DC	Clear Mask Register
00F	0DE	Write All Mask Register Bits

34. 8255 PIO (PC/XT)

Port A = 60 - Read Keyboard Scan Code
or Power-on Diagnostic Outputs

Port B = 61 - Write

Bit 7	-Enable Keyboard / +Clear Keyboard
Bit 6	-Hold Keyboard Clock Low
Bit 5	-Enable I/O Channel Check
Bit 4	-Enable RAM Parity Check
Bit 3	-Read High / +Read Low Switches
Bit 2	Spare (often used for Turbo)
Bit 1	+Speaker Data
Bit 0	+ Timer 2 Gate Speaker

Port C = 62 - Read

Bit 7	+RAM Parity Check
Bit6	+I/O Channel Check
Bit 5	+Timer 2 Out
Bit 4	Spare
Bit 3	Switch Bit 4 or 8
Bit 2	Switch Bit 3 or 7
Bit 1	Switch Bit 2 or 6
Bit 0	Switch Bit 1 or 5

Control Port = 63

Normal Configuration Byte = 99 (Hex)

35. AT 8255 Equivalent

Instead of an 8255 PIO, the AT uses an 8042 Keyboard Controller at ports 60 and 64, and an emulated read/write port at 61 to perform similar functions.

Hex		**Name**	**Description**
60		**Data**	**8042 KB Controller Data Port**
61		**Status**	**Emulated 8255 R/W Port B**
Bit 7	r	PCK	System memory parity check
Bit 6	r	CHK	I/O channel check
Bit 5	r	T2O	Timer 2 output
Bit 4	r	RFD	Refresh Detect
Bit 3	r/w	EIC	enable I/O channel check
Bit 2	r/w	ERP	enable memory parity check
Bit 1	r/w	SPK	speaker data
Bit 0	r/w	T2G	Timer 2 gate (speaker)

64 Control/Status 8042 KB Controller

Control Commands

20	Read Controller
60	Write Controller
AA	Self Test
AB	Interface Test
AC	Diagnostic Dump
AD	Disable Keyboard
AE	Enable Keyboard
C0	Read Discrete Input Port
D0	Read Discrete Output Port
D1	Write Discrete Output Port
E0	Read T0 and T1 inputs
F0-FF	Pulse Discrete Output Port

Status Inputs

Bit 7	1 = Parity Error
Bit 6	1 = RX Timeout
Bit 5	1 = Tx Timeout
Bit 4	1 = KB Inhibited
Bit 3	1 = Command, 0 = Data
Bit 2	1 = Reset OK, 0 = power on
Bit 1	1 = input buffer full
Bit 0	1 = output buffer full

35. AT 8255 Equivalent (cont.)

The AT KB controller also has a discrete input port and a discrete output port. These are accessed with the read/write port commands and are used as follows:

Discrete Input Port

Bit 7	KB Inhibit Switch, 0 = locked
Bit 6	Video Default, 0 = CGA, 1 = MDA
Bit 5	MFG Jumper, 0 = jumper, 1 = no jumper
Bit 4	System RAM, 0 = 512K, 1 = 256K

Discrete Output Port

Bit 7	KB Serial Data Out
Bit 6	KB Serial Clock Out
Bit 5	Input Buffer Empty, 0 = full, 1 = empty
Bit 4	Output Buffer Empty, 0 = empty, 1 = full
Bit 1	Gate A20
Bit 0	System Reset

36. 8259 Interrupt Controller(s)

Note: The 8259 Programmable Interrupt Controller accesses an internal register set through two I/O ports. The 8259 is Initialized by loading up to a 4-byte configuration sequence. It then responds in an Operation Mode. Configuration bytes may vary somewhat due to hardware implementations. The port usage shown below is in the Operation Mode.

Interrupt Controller #1 Ports are 20-21
Interrupts are positive-edge sense.
Port 20 is used to acknowledge and re-enable the 8259
To send non-specific end-of-interrupt code:

```
        mov   al,20h
        out   20h,al
```

Port 21 is used to set/clear the masking register
A Mask Bit = 0 => enable, 1 => disable a specific IRQ
To read Interrupt Mask Register

```
        in      al,21h Bit 7-0 = IRQ 7-0
```

To write Interrupt Mask Register

```
        mov   al,mask
        out   21h,al
```

For 8259 #2 (AT Only)
Interrupt Controller #1 Ports are A0-A1
Interrupts are positive-edge sense.
Port A0 is used to acknowledge and re-enable the 8259
To send non-specific end-of-interrupt code:

```
        mov   al,20h
        out   0A0h,al
```

Port A1 is used to set/clear the masking register
A Mask Bit = 0 => enable, 1 => disable a specific IRQ
To read Interrupt Mask Register

```
        in      al,0A1h        Bit 7-0 = IRQ 15-8
```

To write Interrupt Mask Register

```
        mov   al,mask
        out   0A1h,al
```

37. 8253/8254 Counter/Timer

Port	Section	Description
40	Counter 0	Real Time Clock Tick Count = 0FFFFh Output to IRQ0 every 53 ms. (18.2 ticks per second)
41	Counter 1	DRAM Refresh Count = 0012h Output to DRQ0 (XT) Refresh Logic (AT) (Refresh approx every 15 usec.)
42	Counter 2	Speaker Oscillator Gated by Bit 0 of 8255 Port B
43	Control Register	
	Bit 7, 6	Select Counter 0, 1, 2
	Bit 5, 4	Latch, LSB, MSB, LSB-MSB
	Bit 3, 2, 1	Mode 0 - Interrupt on count 1 - One-shot 2 - Rate generator 3 - Square Wave generator 4 - Triggered strobe (software) 5 - Triggered strobe (hardware)
	Bit 0	Binary/BCD counting

Note: The internal count registers of the 8253/8254 operate in a down-counter mode. If reading register counts for high-resolution timing routines, each count from counter 0 is = 1/1.19318Mhz, or .8380966 usecs. A reload (after the count reaches zero) occurs approximately every 53 millisecs.

38. 8250 Serial Chip Notes

XT/AT Serial Ports may be implemented with a variety of chips, all variations of the 8250 architecture. There are some differences between members of the 8250 family, however, which may cause operational anomalies. The common chip types are labeled:

INS8250
INS8250-B
INS8250A
INS82C50A
NS16450
NS16C450
NS16550A

The INS8250 and INS8250-B had slow access cycle delays, requiring extra NOPS between CPU read/write cycles.

The INS8250 had an "interrupt pending" glitch which was corrected on later versions.

The INS8250A corrected some bugs, which were desired by BIOS coding, possibly making them incompatible with some software packages.. The scratch register (#7) was included on the INS8250A and NS16450/16C450/16550A versions.

The NS16550A includes TX and RX FIFO's, DMA interface, and higher baud rates.

When selecting or replacing 8250 family chips, the preferred type is one of the 16550 series.

39. 8250 Register Description

Register	Reg#	7	6	5	4	3	2	1	0
DATA	0	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
DLL	0		Baud Rate Gen. LSB Divide Count (DLAB = 1)						
DLH	1		Baud Rate Gen. MSB Divide Count (DLAB = 1)						
IER	1	0	0	0	-	Modem Int. Enab.	Rx line Int. Enab	Tx data Int. Enb.	Rx Data Int. Enb.
IIR	2	0	0	0	0	0	Active Int. Bit 0	Active Int. Bit 1	Int. Pending
LCR	3	DLAB Divisor Latch Bit	Set Break Break Bit 2	Parity Mode Bit 1	Parity Mode Bit 0	Parity Mode Bit 0	Stop Bit Length Bit 1	Char Length Bit 0	Char Length
MCR	4	0	0	0	Loopback	-OUT2	0	-RTS	DTR
LSR	5	0	TEMT	THRE	Break	Framing	Parity	Overrun	Rx Rdy
MSR	6	DCD	RI	DSR	CTS	DDCD	TERI	DDSR	DCTS
SCR	7			Scratch-Pad Register					

40. Logical & Physical Devices

There is often confusion about the logical names COM1-4, LPT1-3 and their physical I/O addresses. For example, LPT1: is not always found at the same address. The reason is that the port addresses are scanned by the BIOS in a particular order, and the first device found is labeled #1. The port addresses found this way are stored in a device list.

Therefore a particular physical address does not guarantee that a device will be assigned a particular device number.

The order in which the physical devices are scanned is:

COM Ports: 3F8, 2F8, 3E8, 2E8

LPT Ports: 3BC, 378, 278

To inspect the port lists, use DEBUG:

```
dw 40:0 7 = COM list
dw 40:8 F = LPT list
```

If using AT BiosKit or SysKit, the "SI" command will display the addresses of the ports installed in the system.

41. User ROM Scan

The BIOS provides a means whereby builders of adapter cards may hook into the power-on initialization sequence.

During POST, the BIOS loads a set of default vectors into the appropriate BIOS interrupt addresses. Then the BIOS scans memory addresses C8000 to F4000 in 2K blocks looking for valid modules on the I/O bus.

A valid module will have 55H as byte 0, AAH as byte 1, and a length indicator in byte 2. The length byte is the number of 512 byte blocks over which a checksum (modulo hex 100) must be zero. (The length byte must not exceed FBh, regardless of the length of your code, so you must force a sum of 00 starting with byte 0 up to whatever length byte 3 represents. Your actual code may be longer, but an error will occur if the length byte is larger than FBh.)

Your initialization code must start in Byte 3, since the BIOS will do a Far Call there if the module is found to be valid (passes the three tests above). If you will want control back later when the computer boots, this is also your chance to change the boot vector to point to the entry point for your code. At the end, do a Far Return so the BIOS can finish the power-on routines. If you have changed the boot vector to point to your entry point, you will regain control when the computer boots.

If your module is correct, it will start with 55 AA, and will have a checksum of 00 over the distance indicated by the length code in byte 2. (The length code will be divisible by four.)

42. PC/XT Keyboard Scan Codes

Key #	Scan	Base	Upper	CTRL	ALT
1	01	Esc	Esc	Esc	-
2	02	1	!	-	ext
3	03	2	@	NUL	ext
4	04	3	#	-	ext
5	05	4	$	-	ext
6	06	5	%	-	ext
7	07	6	^	RS	ext
8	08	7	&	-	ext
9	09	8	*	-	ext
10	0A	9	(	-	ext
11	0B	0	)	-	ext
12	0C	-	_	US	ext
13	0D	=	+	-	ext
14	0E	Bspace	Bspace	DEL	-
15	0F	Tab	Ext	-	-
16	10	q	Q	DC1	ext
17	11	w	W	ETB	ext
18	12	e	E	ENQ	ext
19	13	r	R	DC2	ext
20	14	t	T	DC4	ext
21	15	y	Y	EM	ext
22	16	u	U	NAK	ext
23	17	i	I	HT	ext
24	18	o	O	SI	ext
25	19	p	P	DLE	ext
26	1A	[	{	ESC	-
27	1B	]	}	GS	-
28	1C	Enter	Enter	LF	-
29	1D	Ctrl	-	-	-
30	1E	a	A	SOH	ext
31	1F	s	S	DC3	ext
32	20	d	D	EOT	ext
33	21	f	F	ACK	ext
34	22	g	G	BEL	ext
35	23	h	H	BS	ext
36	24	j	J	LF	ext
37	25	k	K	VT	ext
38	26	l	L	FF	ext
39	27	;	:	-	-
40	28	'	"	-	-
41	29	`	~	-	-
42	2A	Lt Shift	-	-	-
43	2B	\	|	FS	-

42. PC/XT Keyboard Scan Codes (cont.)

Key #	Scan	Base	Upper	CTRL	ALT
44	2C	z	Z	SUB	ext
45	2D	x	X	CAN	ext
46	2E	c	C	ETX	ext
47	2F	v	V	SYN	ext
48	30	b	B	STX	ext
49	31	n	N	SO	ext
50	32	m	M	CR	ext
51	33	,	<	-	-
52	34	.	>	-	-
53	35	/	?	-	-
54	36	Rt Shift	-	-	-
55	37	*	PSc	ext	-
56	38	Alt	-	-	-
57	39	Space	Space	Space	Space
58	3A	Caps Lk	-	-	-
59	3B	F1	ext	ext	ext
60	3C	F2	ext	ext	ext
61	3D	F3	ext	ext	ext
62	3E	F4	ext	ext	ext
63	3F	F5	ext	ext	ext
64	40	F6	ext	ext	ext
65	41	F7	ext	ext	ext
66	42	F8	ext	ext	ext
67	43	F9	ext	ext	ext
68	44	F10	ext	ext	ext
69	45	Num Lk	-	pause	-
70	46	Scroll Lk	-	break	*
71	47	Home	N/A		ext
72	48	Up		N/A	-
73	49	PgUp	N/A		ext
74	4A	Pad -		N/A	-
75	4B	Lft		N/A	ext
76	4C	Pad 5	N/A		-
77	4D	Rt		N/A	ext
78	4E	Pad +	N/A		-
79	4F	End		N/A	ext
80	50	Dn		N/A	ext
81	51	PgDn	N/A		ext
82	52	Ins		N/A	-
83	53	Del	-	**	**

NOTES:

ext = extended (returns 00 followed by scan code)

* BiosKit - Ctr-Alt-Break = Enter SysVue

** Ctrl-Alt-Del = Warm Boot

Make (down-key) codes shown; Break codes add 80H

43. AT-84 Key Keyboard Scan Codes

Key #	Scan Code	Base Case	Upper Case	CTRL	ALT
1	0E	`	~	-	-
2	16	1	!	-	ext
3	1E	2	@	NUL	ext
4	26	3	#	-	ext
5	25	4	$	-	ext
6	2E	5	%	-	ext
7	36	6	^	RS	ext
8	3D	7	&	-	ext
9	3E	8	*	-	ext
10	46	9	(	-	ext
11	45	0	)	-	ext
12	4E	-	_	US	ext
13	55	=	+	-	ext
14	5D	\	|	FS	-
15	56	Bspace	Bspace	DEL	-
16	0D	Tab	Ext	-	-
17	15	q	Q	DC1	ext
18	1D	w	W	ETB	ext
19	24	e	E	ENQ	ext
20	2D	r	R	DC2	ext
21	2C	t	T	DC4	ext
22	35	y	Y	EM	ext
23	3C	u	U	NAK	ext
24	43	i	I	HT	ext
25	44	o	O	SI	ext
26	4D	p	P	DLE	ext
27	54	[	{	ESC	-
28	5B	]	}	GS	-
30	14	Ctrl	-	-	-
31	1C	a	A	SOH	ext
32	1B	s	S	DC3	ext
33	23	d	D	EOT	ext
34	2B	f	F	ACK	ext
35	34	g	G	BEL	ext
36	33	h	H	BS	ext
37	3B	j	J	LF	ext
38	42	k	K	VT	ext
39	4B	l	L	FF	ext
40	4C	;	:	-	-
41	52	'	"	-	-
43	5A	Enter	Enter	LF	-
44	12	Lt Shift	-	-	-
46	1A	z	Z	SUB	ext
47	22	x	X	CAN	ext
48	21	c	C	ETX	ext

43. AT-84 Key Keyboard (cont.)

49	2A	v	V	SYN	ext
50	32	b	B	STX	ext
51	31	n	N	SO	ext
52	3A	m	M	CR	ext
53	41	,	<	-	-
54	49	.	>	-	-
55	4A	/	?	-	-
57	59	Rt Shift	-	-	-
58	11	Alt	-	-	-
61	29	Space	Space	Space	Space
64	58	Caps Lk	-	-	-
65	06	F2	ext	ext	ext
66	0C	F4	ext	ext	ext
67	0B	F6	ext	ext	ext
68	0A	F8	ext	ext	ext
69	09	F10	ext	ext	ext
70	05	F1	ext	ext	ext
71	04	F3	ext	ext	ext
72	03	F5	ext	ext	ext
73	B3	F7	ext	ext	ext
74	01	F9	ext	ext	ext
75	70	Insert	-	-	-
90	76	Esc	Esc	Esc	-
91	BC	Home	N/A	ext	-
92	6B	Lft	N/A	ext	-
93	69	End	N/A	ext	-
95	77	Num Lk	-	pause	-
96	75	Up	N/A	-	-
97	73	Pad 5	N/A	-	-
98	72	Dn	N/A	ext	-
99	70	Ins	N/A	-	-
100	7E	Scroll Lk	-	break	*
101	7D	PgUp	N/A	ext	-
102	74	Rt	N/A	ext	-
103	7A	PgDn	N/A	ext	-
104	71	Del	-	**	**
105	78	sys req	-	-	-
106	7C	pad *	prt scr	-	-
107	7B	Pad -	N/A	-	-
108	79	Pad +	N/A	-	-

NOTES: (See also Notes at end of Section 44)

ext = extended (returns 00 followed by scan code)
* BiosKit - Ctrl-Alt-Break = Enter SysVue
** Ctrl-Alt-Del = Warm Boot
** BiosKit - Ctrl-Alt-Shift-Del = Cold Boot

Make (down-key) shown; Break followed by F0H.

44. AT 101-Key Keyboard Scan Codes

Key #	Scan Code	Base Case	Upper Case	CTRL	ALT
1	0E	`	~	-	-
2	16	1	!	-	ext
3	1E	2	@	NUL	ext
4	26	3	#	-	ext
5	25	4	$	-	ext
6	2E	5	%	-	ext
7	36	6	^	RS	ext
8	3D	7	&	-	ext
9	3E	8	*	-	ext
10	46	9	(	-	ext
11	45	0	)	-	ext
12	4E	-	_	US	ext
13	55	=	+	-	ext
15	56	Bspace	Bspace	DEL	-
16	0D	Tab	Ext	-	-
17	15	q	Q	DC1	ext
18	1D	w	W	ETB	ext
19	24	e	E	ENQ	ext
20	2D	r	R	DC2	ext
21	26	t	T	DC4	ext
22	35	y	Y	EM	ext
23	3C	u	U	NAK	ext
24	43	i	I	HT	ext
25	44	o	O	SI	ext
26	4D	p	P	DLE	ext
27	54	[	{	ESC	-
28	5B	]	}	GS	-
29	5D	\	|	FS	-
30	58	Caps Lk	-	-	-
31	16	a	A	SOH	ext
32	1B	s	S	DC3	ext
33	23	d	D	EOT	ext
34	2B	f	F	ACK	ext
35	34	g	G	BEL	ext
36	33	h	H	BS	ext
37	3B	j	J	LF	ext
38	42	k	K	VT	ext
39	4B	l	L	FF	ext
40	4C	;	:	-	-
41	52		"	-	-
43	5A	Enter	Enter	LF	-
44	12	Lt Shift	-	-	-
46	1A	z	Z	SUB	ext
47	22	x	X	CAN	ext
48	21	c	C	ETX	ext

44. AT 101-Key Keyboard (cont.)

Key #	Scan Code	Base Case	Upper Case	CTRL	ALT
49	2A	v	V	SYN	ext
50	32	b	B	STX	ext
51	31	n	N	SO	ext
52	3A	m	M	CR	ext
53	41	,	<	-	-
54	49	.	>	-	-
55	4A	/	?	-	-
57	59	Rt Shift	-	-	-
58	14	Lt Ctrl	-	-	-
60	11	Lt Alt	-	-	-
61	29	Space	Space	Space	Space
62	E0,11	Rt Alt	-	-	-
64	E0,14	Rt Ctrl	-	-	-
75	E0,70	Insert	-	-	-
76	E0,71	Delete	-	-	-
79	E0,6B	Lt Arrow	-	-	-
80	E0,6C	Home	-	-	-
81	E0,69	End	-	-	-
83	E0,75	Up Arrow	-	-	-
84	E0,72	Dn Arrow	-	-	-
85	E0,7D	PgUp	-	-	-
86	E0,7A	PgDn	-	-	-
89	E0,74	Rt Arrow	-	-	-
90	77	Num Lock	-	-	-
91	6C	pad 7	Home	-	-
92	6B	pad 4	Lt Arrow	-	-
93	69	pad 1	End	-	-
95	E0,4A	pad /	pad /	-	-
96	75	pad 8	Up Arrow	-	-
97	73	pad 5	-	-	-
98	72	pad 2	Dn Arrow	-	-
99	70	pad 0	Insert	-	-
100	7C	pad *	pad *	-	-
101	7D	pad 9	PgUp	-	-
102	74	pad 6	Rt Arrow	-	-
103	7A	pad 3	PgDn	-	-
104	71	pad .	Delete	-	-
105	7B	pad -	pad -	-	-
106	79	pad +	pad +	-	-
108	E0,5A	pad Enter	pad Enter	-	-
110	76	Esc	Esc	-	-

44. AT 101-Key Keyboard (cont.)

Key #	Scan Code	Base Case	Upper Case	CTRL	ALT
112	05	F1	ext	ext	ext
113	06	F2	ext	ext	ext
114	04	F3	ext	ext	ext
115	0C	F4	ext	ext	ext
116	03	F5	ext	ext	ext
117	0B	F6	ext	ext	ext
118	83	F7	ext	ext	ext
119	0A	F8	ext	ext	ext
120	01	F9	ext	ext	ext
121	09	F10	ext	ext	ext
122	7B	F11	ext	ext	ext
123	07	F12	ext	ext	ext
124	Note 1	PrtSc	-	-	-
125	7E	Scr Lk	-	-	-
126	Note 2		Pause-Break		

NOTES:
ext = extended (returns 00 followed by scan code)
Pause-Break = CTRL and Num Lock combination
Ctrl-Alt-Del = Warm Boot

For BiosKit:
Ctrl-Alt-Break = Enter SysVue
Ctrl-Alt-Shift-Del = Cold Boot

Note 1: Print Screen Key: Down code, E0 12 E0 7C,
Up code, E0 F0 7C E0 F0 12
If Crtl down, Down code, E0 7C,
Up code E0 F0 7C
If Alt down, Down code, B4, Up code D0 B4

Note 2: Pause Key: Down code, E1 14 77 E1 F0 14 F0 77,
Up code, none
Break is active when Crtl is down:
Down code E0 7E E0 F0 7E, Up code, none

Keyboard information extracted from "PC Keyboard Design", by Gary Konzak (Annabooks).
Also see this reference for the 101-key XT Keyboard scan codes.

45. AT Keyboard Commands

The AT Keyboards can accept commands initiated by the system and sent through the 8042 keyboard controller. More detailed information on the use of these commands is included in the IBM AT Technical Reference Manual.

Commands to Keyboard

Hex	Name	Description
F5	Default Disable	Resets all conditions to default state, stops scanning.
EE	Echo	Instruct KB to echo an EE code.
F4	Enable	KB replies with ACK, resumes scanning.
FE	Resend	KB resends last output.
FF	Reset	Resets KB.
F6	Set Default	Reset KB to default state.
F3	Set Typematic Rate/Delay	Set repeat and delay conditions for keys.
ED	Set/Reset Mode Indicators	Set or rest the LED's according to contents of following byte.
F2	Read ID code.	Tells KB to respond with 2-byte ID
F0	Select Scan Code Set	Tells KB which internal scan code set to use.
F7-FA	Set All Keys	Sets typematic and make/break operation of KB.
FB-FD	Set Key Types	Sets typematic and make/break operation for specific keys.

Commands to System

Hex	Name	Description
FA	ACK	Acknowledge to a command.
AA	Test OK	Internal Diagnostic OK.
F0	Break Prefix	Following scan code byte signifies key release.
FD	Diagnostic Failure	Internal diagnostic failed.
EE	Echo Response	Response to ECHO Command.
00 and FF	Error buffer overrun or an unidentified key.	These two codes may indicate a

46. ASCII Control Codes

Hex	Dec	Key	Name	Description
00	0	^@	NUL	Null
01	1	^A	SOH	Start of Header
02	2	^B	STX	Start of Text
03	3	^C	ETX	End of Text
04	4	^D	EOT	End of Transmission
05	5	^E	ENQ	Enquiry
06	6	^F	ACK	Acknowledge
07	7	^G	BEL	Bell
08	8	^H	BS	Backspace
09	9	^I	HT	Horizontal Tab
0A	10	^J	LF	Line Feed
0B	11	^K	VT	Vertical Tab
0C	12	^L	FF	Form Feed
0D	13	^M	CR	Carriage Return
0E	14	^N	SO	Shift Out
0F	15	^O	SI	Shift In
10	16	^P	DLE	Data Link Escape
11	17	^Q	DC1	Device Control 1
12	18	^R	DC2	Device Control 2
13	19	^S	DC3	Device Control 3
14	20	^T	DC4	Device Control 4
15	21	^U	NAK	Negative Acknowledge
16	22	^V	SYN	Synchronous Idle
17	23	^W	ETB	End Transmission Block
18	24	^X	CAN	Cancel
19	25	^Y	EM	End of Medium
1A	26	^Z	SUB	Substitute
1B	27	^[	ESC	Escape
1C	28	^\	FS	File Separator
1D	29	^]	GS	Group Separator
1E	30	^^	RS	Record Separator
1F	31	^_	US	Unit Separator

Key column refers to combination of CTRL key and specified key to generate control code.

47. Screen Codes

Dec.	Hex	Sym.	Dec.	Hex	Sym.
0	00		32	20	
1	01	☺	33	21	!
2	02	☻	34	22	"
3	03	♥	35	23	#
4	04	♦	36	24	$
5	05	♣	37	25	%
6	06	♠	38	26	&
7	07	•	39	27	'
8	08	◘	40	28	(
9	09	○	41	29	)
10	0A	■	42	2A	*
11	0B	♂	43	2B	+
12	0C	♀	44	2C	,
13	0D	♪	45	2D	-
14	0E	♫	46	2E	.
15	0F	☼	47	2F	/
16	10	►	48	30	0
17	11	◄	49	31	1
18	12	↕	50	32	2
19	13	‼	51	33	3
20	14	¶	52	34	4
21	15	§	53	35	5
22	16	▬	54	36	6
23	17	↨	55	37	7
24	18	↑	56	38	8
25	19	↓	57	39	9
26	1A	→	58	3A	:
27	1B	←	59	3B	;
28	1C	∟	60	3C	<
29	1D	↔	61	3D	=
30	1E	▲	62	3E	>
31	1F	▼	63	3F	?

47. Screen Codes (cont.)

Dec.	Hex	Sym.	Dec.	Hex	Sym
64	40	@	96	60	`
65	41	A	97	61	a
66	42	B	98	62	b
67	43	C	99	63	c
68	44	D	100	64	d
69	45	E	101	65	e
70	46	F	102	66	f
71	47	G	103	67	g
72	48	H	104	68	h
73	49	I	105	69	i
74	4A	J	106	6A	j
75	4B	K	107	6B	k
76	4C	L	108	6C	l
77	4D	M	109	6D	m
78	4E	N	110	6E	n
79	4F	O	111	6F	o
80	50	P	112	70	p
81	51	Q	113	71	q
82	52	R	114	72	r
83	53	S	115	73	s
84	54	T	116	74	t
85	55	U	117	75	u
86	56	V	118	76	v
87	57	W	119	77	w
88	58	X	120	78	x
89	59	Y	121	79	y
90	5A	Z	122	7A	z
91	5B	[	123	7B	{
92	5C	\	124	7C	|
93	5D	]	125	7D	}
94	5E	^	126	7E	~
95	5F	_	127	7F	▒

47. Screen Codes (cont.)

Dec.	Hex	Sym.	Dec.	Hex	Sym.
128	80	Ç	160	A0	á
129	81	ü	161	A1	í
130	82	é	162	A2	ó
131	83	â	163	A3	ú
132	84	ä	164	A4	ñ
133	85	à	165	A5	Ñ
134	86	å	166	A6	ª
135	87	ç	167	A7	º
136	88	ê	168	A8	¿
137	89	ë	169	A9	⌐
138	8A	è	170	AA	¬
139	8B	ï	171	AB	½
140	8C	î	172	AC	¼
141	8D	ì	173	AD	¡
142	8E	Ä	174	AE	«
143	8F	Å	175	AF	»
144	90	É	176	B0	░
145	91	æ	177	B1	▒
146	92	Æ	178	B2	▓
147	93	ô	179	B3	│
148	94	ö	180	B4	┤
149	95	ò	181	B5	╡
150	96	û	182	B6	╢
151	97	ù	183	B7	╖
152	98	ÿ	184	B8	╕
153	99	Ö	185	B9	╣
154	9A	Ü	186	BA	║
155	9B	¢	187	BB	╗
156	9C	£	188	BC	╝
157	9D	¥	189	BD	╜
158	9E	₧	190	BE	╛
159	9F	ƒ	191	BF	┐

47. Screen Codes (cont.)

Dec.	Hex	Sym.	Dec.	Hex	Sym.
192	C0	└	224	E0	α
193	C1	┴	225	E1	β
194	C2	┬	226	E2	Γ
195	C3	├	227	E3	π
196	C4	─	228	E4	Σ
197	C5	┼	229	E5	σ
198	C6	╞	230	E6	μ
199	C7	╟	231	E7	τ
200	C8	╚	232	E8	Φ
201	C9	╔	233	E9	Θ
202	CA	╩	234	EA	Ω
203	CB	╦	235	EB	δ
204	CC	╠	236	EC	∞
205	CD	═	237	ED	φ
206	CE	╬	238	EE	ϵ
207	CF	╧	239	EF	∩
208	D0	╨	240	F0	≡
209	D1	╤	241	F1	±
210	D2	╥	242	F2	≥
211	D3	╙	243	F3	≤
212	D4	╘	244	F4	⌠
213	D5	╒	245	F5	⌡
214	D6	╓	246	F6	÷
215	D7	╫	247	F7	≈
216	D8	╪	248	F8	°
217	D9	┘	249	F9	∙
218	DA	┌	250	FA	·
219	DB	█	251	FB	√
220	DC	▄	252	FC	η
221	DD	▌	253	FD	²
222	DE	▐	254	FE	■
223	DF	▀	255	FF	

48. Line Drawing Character Codes

To enter these characters, hold down ALT Key while entering the decimal code for the character on the numeric keypad.

```
218   196   194   196   191
┌     ─     ┬     ─     ┐

179         179         179
│           │           │

195   196   197   196   180
├     ─     ┼     ─     ┤

179         179         179
│           │           │

192   196   193   196   217
└     ─     ┴     ─     ┘

---------------------------

201   205   203   205   187
╔     ═     ╦     ═     ╗

186         186         186
║           ║           ║

204   205   206   205   185
╠     ═     ╬     ═     ╣

186         186         186
║           ║           ║

200   205   202   205   188
╚     ═     ╩     ═     ╝
```

48. Line Drawing Character Codes (cont.)

To enter these characters, hold down ALT Key while entering the decimal code for the character on the numeric keypad.

213	205	209	205	184
╒	═	╤	═	╕
179		179		179
│		│		│
198	205	216	205	181
╞	═	╪	═	╡
179		179		179
│		│		│
212	205	207	205	190
╘	═	╧	═	╛

214	196	210	196	183
╓	─	╥	─	╖
186		186		186
║		║		║
199	196	215	196	182
╟	─	╫	─	╢
186		186		186
║		║		║
211	196	208	196	189
╙	─	╨	─	╜

49. DOS Commands

Append: APPEND [[/x][/e]]|[;]|[[drive:]path[;[drive:]path...]|[[path][/x[:on]|[:off]][/path:[on][off]]]
Assign: ASSIGN [X[=]Y[...]]
Attribute: ATTRIB[+R|-R][+A|-A][drive:]pathname[/s]
Backup: BACKUP source destination [/A][/D:mm-dd-yy][/L:filename][/M][/P][/S][/T:hh:mm]
Run Program: [drive:]filename[parameters]
Break: BREAK [ON|OFF]
Change Code Page: CHCP [nnnn]
Change Dir: CHDIR|CD [[drive:]path]|[..]
Check Disk: CHKDSK [drive:][filename][/F][/V]
Clear Screen: CLS
Shell: [DOSSHELL|COMMAND][drive:][path][device][/E:n][/P][/C string]
Compare Files: COMP [[d:][path][filename]][[d:][path][filename]
Copy: COPY source [/A][/B][+source[/A][/B]...][destination[/A][/B][/V]
Console: CTTY device
Date: DATE [[mm-dd-yy]|[mm/dd/yy]|[mm.dd.yy]]
Directory: DIR [drive:][path][filename][/P][/W]
Disk Compare: DISKCOMP [drive1:][drive2:][/1][/8]
Disk Copy: DISKCOPY [drive1:][drive2:][/1]
Erase: ERASE|DEL [drive:][path]filename
Exe to Bin: EXE2BIN [drive:]pathname1 [drive:]pathname2
Exit: EXIT (return to previous level)
Fastopen: FASTOPEN drive: [[=n]|[=(n,m)]][/X]

49. **DOS Commands** (cont.)

```
File Compare:  FC[/A][/C][/L][/LBn][/N][/nnnn][/T][/W][drive:]pathname1 [drive:]pathname2
               FC[/B][drive:]pathname1 [drive:]pathname2
Fdisk:         FDISK
Find:          FIND:[/C][/N][/V] "string" [[drive:][path]filename] [[drive:][path]filename...]
Format:        FORMAT [drive:][/S][/1][/4][/8][/N:n][/T:n][/V][/B][/S][f:size]]
Install:       INSTALL = [drive:][path]filename
Load Graphics: GRAFTABL[437|860|863|865]|/STA[TUS]]|[?]
Screen Print:  GRAPHICS[printer][profile][/R][/B][/LCD][/C][/F][/P port][/printbox:id]
Join:          JOIN[[ drive1:][/D][drive2:path]]
Define KB:     KEYBxx where xx = US FR GR IT SP UK ...
Label:         LABEL [drive:][label]
Make Dir:      MKDIR|MD [drive:][path]new-directory
Mem:           MEM [/program]][/debug]
Mode:          MODE LPTn[:][=COMn[:][80|132 (cols)][,[[RETRY=[E|B|R]]|[LINES=[6|8]][,P]]
               MODE [40|80|BW40|BW80|CO40|CO80|MONO][25|43|50|R|L][,T (test)]n
               MODE COMn[:][110|150|300|1200|2400|4800|9600[,N|O|E[,7|8[,1|2[,P]]]]
               MODE CON [COLS=m][LINES=n][RATE=r][DELAY=d]
               MODE device CP [PREP=((cplist) filename)][SELECT=CP][/STATUS]
More:          MORE < source (or source|MORE)
Extended Country:  NLSFUNC [[d:][path]filename[.ext]
Path:          PATH [drive:]path[[;[drive:]path]...]
```

49. DOS Commands (cont.)

Print:	PRINT[[drive:][filename][/T][/C][/P]..]] PRINT[/D:device][/B:n][/M:n][/Q:n][/S:n][/U:n][[drive:][path]filename][/C][/P]...]]
Prompt:	PROMPT [string] (common usage is pg)
Recover:	RECOVER [drive:][path]filename]
Rename:	REN[AME][drive:][path]oldname newname
Replace:	REPLACE [drive:]pathname [drive:][path][/A][/D][/P][/R][/S][/W]
Restore:	RESTORE drive1: [drive2:][pathname][/A:date][/B:date][/E:time][/L:time][/M][/N][/S][/P]
Remove Dir:	RMDIR|RD [drive:][path]directory-name
Select:	SELECT[[drive1:]drive2:[path]] country keyboard
Set:	SET[name=[value]]
Share:	SHARE[/F:n][/L:n]
Sort:	SORT[/R][/+column] (alphabetic sort filter)
Substitue:	SUBST[drive1[[/D]|[[drive2:]path]]
System:	SYS drive:
Time:	TIME [hh:mm[:ss[.xx]]][a|p]
Tree:	TREE [drive:][/F]
Type:	TYPE [drive:][path]filename
Version:	VER
Verify:	VERIFY [ON|OFF]
Volume:	VOL [drive:]
Xcopy:	XCOPY source [destination][/A][/DRIVE:mm-dd-yy][/E][/M][/P][/S][/V][/W]

50. DEBUG Commands

Starting:	DEBUG [d:][path][filename][parm1][parm2]
Ending:	Q
Assemble:	A[address]
Compare:	C range address
Dump:	D[address] or D[range]
Enter:	E address [list]
Fill:	F range list
Go:	G[=address][break0][...break9]]
Hexmath:	H value1 value2
Input:	I port
Load:	L [address[drive, sector#, # of sectors]]
Move:	M range address
Name:	N filespec [parameter...]
Output:	O port byte
Proceed:	P [=address][number]
Quit:	Q
Register:	R [F] I [registername]
Search:	S range list
Trace:	T [=address][number]
Unassemble:	U [address] or U [range]
Write:	W [address [drive, sector#, # of sectors]]

51. EDLIN Commands

Starting:	EDLIN[d:][path]filename[/B]
Ending:	E (saves the work) Q (doesn't save the work)

Append Lines:	[n]A
Copy Lines:	[line],[line],line[,count]C
Delete Lines:	[line][,line]D
Edit Line:	[line]
End Edit:	E
Insert Lines:	[line]I (Ctrl-Brk when done)
List Lines:	[line][,line]L
Move Lines:	[line],[line],lineM
Page Display:	[line][,line]P
Quit Edit:	Q
Replace Text:	[line][,line][?]R[string][<f6>string]
Search Text:	[line][,line][?]S[string]
Transfer Lines:	[line]T[d:]filename
Write Lines:	[n]W

52. BATCH Commands

Call:	CALL filename [options]
Display Text:	ECHO [ON|OFF|message]
For:	FOR [%]%variable IN (set) DO command
Jump:	GOTO name
If:	IF [NOT] [[ERRORLEVEL number]|[string1==string2]|[EXIST pathname]] command
Pause:	PAUSE [message]
Remark:	REM [message]
Shift:	SHIFT

53. DOS Keystrokes

Reset: Ctrl-Alt-Del (Warm Boot)
Reset: Ctrl-Alt-Shift-Del (BiosKit Cold Boot)
SysVue: Ctrl-Alt-Break (BiosKit or SysKit)
Stop Scroll: Ctrl-Num Lock or Ctrl-S
Resume Scroll: Any Key
Print Screen: Shift-Prt Sc (Screen dump)
Print Screen: Ctrl-Prt Sc (Continous)
End Operation: Ctrl-Break or Ctrl-C
Next Line: Ctrl-Enter (without CR)
Cancel Line: Esc

54. CONFIG.SYS Commands

```
Break:      BREAK = ON|OFF
Buffers:    BUFFERS = nn
Country:    COUNTRY = nnn[,yyy][,[drive:]filename]
Device:     DEVICE = [drive:][path]filename[options]
            DEVICE = [drive:][path]ANSI.SYS [/X][/L][/K]
            DEVICE = [drive:][path]DISPLAY.SYS CON=([LCD|EGA],hwcp,n)
            DEVICE = [drive:][path]DRIVER.SYS /D:ddd [/T:ttt][/S:ss][/H:hh][/C][/N][/F:f].....
            DEVICE = [drive:][path]PRINTER.SYS LPTn[:]=([4201|4208|5202],hwcp,n)
            DEVICE = [drive:][path]VDISK.SYS [text][bbb][text][sss][text][ddd][/E ][:m]
            DEVICE = [drive:][path]XMAEM.SYS...
            DEVICE = [drive:][path]XMA2EMS.SYS...
Switches    SWITCHES = /K
Sysparms:   DRIVPARM = /D:n[/C][/F:n][/H:n][/N][/S:n][T:n]
Fcbs:       FCBS = m,p
Files:      FILES = n
Drive:      LASTDRIVE = drive
Shell:      SHELL = [drive:][path]filename[options]
Stacks:     STACKS = number,size
```

55. LIB Commands

The LIB (Library) Program requests responses to the following prompts:

Library Name	OldLibrary name (a semicolon (;) immediately after the name causes LIB to perform a consistency check on the OldLibrary).	
Operations	"blank"	No operation.
	-	Delete Module from OldLibrary.
	+	Add Module to OldLibrary.
	-+	Replace Module in OldLibrary.
	*	Copy Module to Object Module or Output Library
	-*	Copy Module and delete from OldLibrary
List File	Name of optional cross reference list file.	
Output Library	NewLibrary name (only if argument in Operations field).	

56. Floppy Disk Formats

3.5" Diskettes

Formatted Capacity	**720K**	**1.44MB**	**2.88MB**
# of heads (Sides)	2	2	2
# of Cyls (Tracks)	80	80	80
# of Sectors/Track	9	18	36
Total # of Sectors	1440	2880	5760
# of Free Sectors	1426	2847	5726
# Sectors/Cluster	2	1	2
Total # of Clusters	713	2847	2863
# Sectors/FAT	3	9	9
# of FAT Copies	2	2	2
# of Root Dir Sectors	7	14	15
# Reserved Sectors	1	1	1
# of Hidden Sectors	0	0	0
# of Bytes/Sector	512	512	512
# of Bytes/Cluster	1024	512	1024
# Root Dir Entries	112	224	240
Media Descriptor	F9	F0	F0
Recorded Density	Double	High	High
DOS Version Began	3.20	3.30	5.00
DRIVER.SYS Switch	/F:2	/F:7	/F:9
FORMAT.EXE Switch	/F:720	/F:1.44	/F:2.88
Change-Line Support	YES	YES	YES

56. Floppy Disk Formats (cont.)

5.25" Diskettes

Formatted Capacity	**160K**	**180K**	**320K**	**360K**	**1.2MB**
# of heads (Sides)	1	1	2	2	2
# of Cyls (Tracks)	40	40	40	40	80
# of Sectors/Track	8	9	8	9	15
Total # of Sectors	320	360	640	720	2400
# of Free Sectors	313	351	630	708	2371
# Sectors/Cluster	1	1	2	2	1
Total # of Clusters	313	351	315	354	2371
# Sectors/FAT	1	2	1	2	7
# of FAT Copies	2	2	2	2	2
# of Root Dir Sectors	4	4	7	7	14
# Reserved Sectors	1	1	1	1	1
# of Hidden Sectors	0	0	0	0	0
# of Bytes/Sector	512	512	512	512	512
# of Bytes/Cluster	512	512	1024	1024	512
# Root Dir Entries	64	64	112	112	224
Media Descriptor	FE	FC	FF	FD	F9
Recorded Density	Double	Double	Double	Double	High
DOS Version Began	1.00	2.00	1.10	2.00	3.00
DRIVER.SYS Sw.	/F:0	/F:0	/F:0	/F:0	/F:1
FORMAT.EXE Sw.	/F:160	/F:180	/F:320	/F:360	/F:1.2
Change-Line Support	NO	NO	NO	NO	YES

57. Disk Controller Function Summary

Information on this and following pages extracted from "Hard Drive Encyclopedia" by Alting-Mees (Annabooks).

ST506	All host interface circuitry located on expansion card. Host to controller communications through Command Description Blocks (Task Descriptor Files or Task Files). Host interface contoller connected to drive controller via 34-pin control cable and 20-pin data cable. MFM data sent from host interface controller to drive controller.
ESDI	Data separator circuit located on drive electronics, all other interface electronics located on expansion card. Host to controller communicaitons through Command Description Blocks. Host interface controller connected to drive controller via 34-pin control cable and 20-pin data cable. NRZ data sent from host interface controller to drive controller.
SCSI	All controller functions and circuitry located on drive. Host adapter (rather than interface controller) required to interface SCSI bus to PC bus. Host to controller communications through Command Description Blocks. Host (or adapter) SCSI software driver must translate from sectors (DOS) to data blocks.
IDE	All controller functions and circuitry located on drive. Host to controller communications through Command Description Blocks. Host computer or IDE adapter board connected to drive via 40-pin cable.

59. ST506 & ESDI Cables

34 Conductor Control Cable

Signal Name	Direction	Signal Pin #	Gnd Pin #
Reserved (sometimes Reduced WC Flag)	N/A	2	1
Head Select 2	>	4	3
Write Gate	>	6	5
Seek Complete	<	8	7
Track 0	<	10	9
Write Fault	<	12	11
Head Select 0*	>	14	13
Sector/Address Mark Found	<	16	15
Head Select 1	>	18	17
Index	<	20	19
Ready	<	22	21
Step	>	24	23
Drive Select 1	>	26	25
Drive Select 2	>	28	27
Drive Select 3	>	30	29
Drive Select 4	>	32	31
Direction	>	34	33

20 Conductor Data Cable

Drive Selected	<	1	2
Reserved	N/A	3	4
Reserved	N/A	5	6
**	N/A	7	8
Reserved	N/A	9	
Reserved	N/A	10	11
+ Write Data	>	13	12
- Write Data	>	14	15
+ Read Data	<	17	16
- Read Data	<	18	19, 20

* = Looped to pin 7 of data connector on the disk
** = Connected to pin 16 of the controller connector on the disk
> = From controller to disk
< = From disk to controller

34-pin connector: AMP 842-807-2005-007 or 3M 3461-0001
20-pin connector: AMP 842-807-3405-007 or 3M 3463-0001

59. ST506 & ESDI Signals

All signals active high.

Direction	Set TRUE when moving heads towards center tracks, set FALSE when moving heads towards outer tracks.
Drive Select	Used by the host to specify drive it wishes to access. On most drives, these lines serve only to gate other interface signals into the drive electronics (from the controller), or vice versa.
Head Select	Three signals used to specify one of eight heads for upcoming read or write operation.
Index	FALSE to TRUE edge. Signals the index mark has just passed under the head; this occurs once each revolution, or 16.67 ms for 3600 rpm.
Ready	Set TRUE when drive speed and DC power are ready and Track 000 has been set TRUE.
Seek Complete	SET TRUE when actuator has moved heads the required step distance. Set FALSE during power on.
Step	Active pulse causes stepper motor to move the heads one track position in the direction indicated by the Direction line.
Track 000	TRUE during power on and when moving the heads from track 001 to 000.
Write Gate	Set TRUE during write operations, FALSE during read operations.
Write Fault	Set TRUE if an error has occurred during the operation. Errors include: - Write current in head without Write Gate true - No write current in head with Write Gate and Drive Select true - Write Gate true, heads off-track and drive selected - DC power out of tolerance
Drive Selected	Set TRUE by the drive to acknowledge that its address matches the Drive Select.
Write Data	Differential data lines that send data to the drive (MFM for ST506, NRZ for ESDI).
Read Data	Differential data lines that read data from the drive (MFM for ST506, NRZ for ESDI).

60. SCSI Cable

The SCSI bus is composed of 8 data bits, one parity bit (odd), nine control lines, 30 ground lines, and one line to supply power to the terminators. Pin 25 is not connected in order to safeguard against accidental shorting of the termination power.

Signal Name	Direction	Signal Pin #	Gnd Pin #
DB0*	<>	2	1
DB1*	<>	4	3
DB2*	<>	6	5
DB3*	<>	8	7
DB4*	<>	10	9
DB5*	<>	12	11
DB6*	<>	14	13
DB7*	<>	16	15
DBP	<>	18	17
GND		20	19
GND		22	21
GND		24	23
TRMPWR	<>	26	
GND		28	27
GND		30	29
ATN*	>	32	31
GND		34	33
BSY*	<>	36	35
ACK*	>	38	37
RST*	<>	40	39
MSG*	<	42	41
SEL*	<>	44	43
C/D*	<	46	45
REQ*	<	48	47
I/O*	<	50	49

* = Active low
> = From initiator to target device
< = From target device to initiator
<> = bi-directional

External terminators: AMP 88-4163-081-1 or
DATA MATE DM500-06-8

Cable: 50 wire flat 28 AWG, 3M 3365-50 or equivalent.

61. SCSI Signals

ACK*	Acknowledge. The initiator asserts this line low when it acknowledges that it has received or supplied data to the target (previously asserted REQ low for data response). Used in all asynchronous REQ/ACK data transfers.
ATN*	Attention. Initiator driven.
BSY*	Busy. OR-tied (on each device) line that indicates the bus is in use. Asserted low by either the initiator, the target, or both.
C/D*	Control/Data. When low, indicates that control information is on the bus. When high, data is present on the bus. Target driven.
DB*<0-7>	Data Bits 0-7. Bi-directional data bus. During Arbitration, Selection, and Reselection, these lines are used to transmit the device ID's, with each data bit corresponding to a different device number.
DBP*	Data Bit Parity. Part of the data bus, but its use is optional in SCSI-1. Odd parity. Must be TRUE during arbitration.
DIFFSENS	Differential Sense. Used on differential SCSI bus only. Enables the differential drivers.
I/O*	Input/Output Direction. Direction of data transfer relative to initiator (input means: to the initiator). Also used to determine Selection and Reselection phases (asserted low during Reselection). Target driven.
MSG*	Message. Indicates that the target has placed a message on the data bus.
REQ*	Request. Target driven. Asserted low when target is ready to begin asynchronnous handshaking with the initiator.
RST*	Reset. OR-tied line that indicates Reset condition.
SEL*	Select. Used by the initiator to select a target device, and used by the target to reselect an initiator.
TRMPWR	Terminator Power. Supplies power to terminating resistors at the ends of the bus.

62. IDE Cable

Signal Name	Direction	Pin #
RESET*	>	1
GND		2
DD7	<>	3
DD8	<>	4
DD6	<>	5
DD9	<>	6
DD5	<>	7
DD10	<>	8
DD4	<>	9
DD11	<>	10
DD3	<>	11
DD12	<>	12
DD2	<>	13
DD13	<>	14
DD1	<>	15
DD14	<>	16
DD0	<>	17
DD15	<>	18
GND		19
KEY PIN		20
DMARQ	<	21
GND		22
DIOW*	>	23
GND		24
DIOR*	>	25
GND		26
IORDY	<	27
Reserved		28
DMACK*	>	29
GND		30
INTRQ	<	31
IOCS16*	<	32
DA1	>	33
PDIAG*	<**	34
DA0	>	35
DA2	>	36
CS1FX*	>	37
CS3FX*	>	38
DASP*	<**	39
GND		40

* = Active low
> = To drive from controller
< = To controller from drive
** = Drive to drive intercommunication

Cable: 40 pin flat or twisted, 3M 3365-40 or equivalent
Connector: 40 pin IDC , Molex 7723 40 A 587 or equivalent
No terminations required

63. IDE Signals

CS1FX*	Chip Select Drive 0. Used to select the host-accessable Command Block Register.
CS3FX*	Chip Select Drive 1. Used to select the host-accessable Command Block Register.
DA0-2	Drive Address Bus. Address used by the host to access a register or the data port in the drive.
DASP*	Drive Active/Drive 1 Present. Indicates drive activity or that drive 1 is present. This is a time multiplexed signal, which is first asserted by drive 1 (if present) and then by drive 0 (to drive an activity LED).
DD<0-15>	Drive Data Bus. An 8 or 16 bit bi-directional data bus between the host and the drive. The lower 8 bits are used for 8 bit transfers (ECC bytes, for example).
DIOR*	Drive I/O Read. Strobe signal for read functions. Negative edge enables data from a register or data port of the drive onto the host data bus. Positive edge latches data at the host.
DMACK*	DMA Acknowledge. Used by the host to acknowledge that data has been accepted or data is available. Used in response to DMARQ asserted.
DMARQ	DMA Request. Used for DMA transfers between host and drive (direction of transfer controlled by DIOR* and DIOW*). Used in an asynchronous mode with DMACK*. Drive asserts DMARQ when ready to transfer or receive data; drive waits until host asserts DMACK* before negating DMARQ and sending 16 bit word.
INTRQ	Drive Interrupt Request. Asserted by drive when it has a pending interrupt (PIO transfer of data to or from the drive to the host).
IOCS16*	Drive 16 bit I/O. Indicates to the host system that the 16 bit data port has been addressed and that the drive is prepared to send or receive a 16 bit data word.
IORDY	I/O Channel Ready (optional). When negated, extends the host transfer cycle of any host register access when the drive is not ready to respond to a data transfer request. High impedance if asserted.

63. IDE Signals (cont.)

PDIAG*	Passed Diagnostics. Output from drive 1 and monitored by drive 0. Provides an indication of the results of a diagnostics command or reset.
RESET*	Resets the drive to the power on state.

Note concerning XT IDE drives: Although most of the IDE drives have been manufactured for the AT, there are a few versions for the XT. The XT drives are equivalent in all respects except for the use of only 8 data lines instead of 16. *Because the remaining 8 data lines are typically grounded, these XT drives should not be connected to the AT bus or to an AT bus extender card!*

The information on this and preceeding pages has been extracted from "Hard Drive Encyclopedia" by Adrian Alting-Mees (Annabooks).

64. Hex Math

Addition:

+	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	10
2	.	4	5	6	7	8	9	A	B	C	D	E	F	10	11
3	.	.	6	7	8	9	A	B	C	D	E	F	10	11	12
4	.	.	.	8	9	A	B	C	D	E	F	10	11	12	13
5	.	.	.	.	A	B	C	D	E	F	10	11	12	13	14
6	.	.	.	.	.	C	D	E	F	10	11	12	13	14	15
7	.	.	.	.	.	.	E	F	10	11	12	13	14	15	16
8	.	.	.	.	.	.	.	10	11	12	13	14	15	16	17
9	.	.	.	.	.	.	.	.	12	13	14	15	16	17	18
A	.	.	.	.	.	.	.	.	.	14	15	16	17	18	19
B	.	.	.	.	.	.	.	.	.	.	16	17	18	19	1A
C	.	.	.	.	.	.	.	.	.	.	.	18	19	1A	1B
D	.	.	.	.	.	.	.	.	.	.	.	.	1A	1B	1C
E	.	.	.	.	.	.	.	.	.	.	.	.	.	1C	1D
F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1E

Subtraction: (Horizontal minus vertical)

-	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
1	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E
2	F	0	1	2	3	4	5	6	7	8	9	A	B	C	D
3	E	F	0	1	2	3	4	5	6	7	8	9	A	B	C
4	D	E	F	0	1	2	3	4	5	6	7	8	9	A	B
5	C	D	E	F	0	1	2	3	4	5	6	7	8	9	A
6	B	C	D	E	F	0	1	2	3	4	5	6	7	8	9
7	A	B	C	D	E	F	0	1	2	3	4	5	6	7	8
8	9	A	B	C	D	E	F	0	1	2	3	4	5	6	7
9	8	9	A	B	C	D	E	F	0	1	2	3	4	5	6
A	7	8	9	A	B	C	D	E	F	0	1	2	3	4	5
B	6	7	8	9	A	B	C	D	E	F	0	1	2	3	4
C	5	6	7	8	9	A	B	C	D	E	F	0	1	2	3
D	4	5	6	7	8	9	A	B	C	D	E	F	0	1	2
E	3	4	5	6	7	8	9	A	B	C	D	E	F	0	1
F	2	3	4	5	6	7	8	9	A	B	C	D	E	F	0

64. **Hex Math** (cont.)

Multiplication:

x	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
1	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
2	.	4	6	8	A	C	E	10	12	14	16	18	1A	1C	1E
3	.	.	9	C	F	12	15	18	1B	1E	21	24	27	2A	2D
4	.	.	.	10	14	18	1C	20	24	28	2C	30	34	38	3C
5	.	.	.	.	19	1E	23	28	2D	32	37	3C	41	46	4B
6	.	.	.	.	.	24	2A	30	36	3C	42	48	4E	54	5A
7	.	.	.	.	.	.	31	38	3F	46	4D	54	5B	62	69
8	.	.	.	.	.	.	.	40	48	50	58	60	68	70	78
9	.	.	.	.	.	.	.	.	51	5A	63	6C	75	7E	87
A	.	.	.	.	.	.	.	.	.	64	6E	78	82	8C	96
B	.	.	.	.	.	.	.	.	.	.	79	84	8F	9A	A5
C	.	.	.	.	.	.	.	.	.	.	.	90	9C	A8	B4
D	.	.	.	.	.	.	.	.	.	.	.	.	A9	B6	C3
E	.	.	.	.	.	.	.	.	.	.	.	.	.	C4	D2
F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	E1

Also available from **Annabooks**

BiosMaker
Source Code in "C" for Building BIOS for PC Compatible Platforms

PromKit
Source Code in "C" for Building Disk-in-Prom Emulators

SysKit
Source Code in "C" for Building Resident Monitor/Setup Programs for non-Annabooks BIOS Equipped Machines

ISA & EISA Theory and Operation
XT - AT - EISA Bus Timing Specifications

Microsoft Licenses
Development Kits and Production Licenses for Rom and Disk Versions of MS-DOS, Windows, and Flash File System for Embedded Systems

PC Keyboard Design
Hardware and Firmware Reference for Using the Keyboard Port on PCs for I/O

Annabooks

15010 Avenue of Science, Suite 101
San Diego, CA 92128-3421

1-800-462-1042 619-673-0870 619-673-1432 FAX

We accept Visa, MasterCard, and American Express

Annabooks

ISBN 0-929392-00-0